Leybourn's Dialling
IMPROV'D
Or, The Whole Art perform'd,

I. *Geometrically* : By Scale and Compasses, by projecting the *Sphere* upon the *Plain*, whereby the Reasons of the Operations are demonstrated.

II. *Arithmetically* : By Sines and Tangents.

ALSO,

How to describe all necessary Furniture for *SUN-DIALS*, as the Sun's Place and Declination ; with the *Babylonish*, *Italick*, and *Jewish* Hours, and the Point of the Compass the Sun is upon at any Time of the Day ; and to make Dials to give the Time of the Day at any Place proposed, in any Part of the World.

WITH

Reflective Dialling : Shewing how to make a Dial that shall give the true Hour of the Day, where the Sun cannot shine.

To which is now added,

Instrumental Dialling : By the Lines of Hours, and Inclination upon the *Scales*, and likewise *Mechanick Dialling*, whereby any Person may, without *Mathematicks*, make a Dial upon any *Plain*; with the Manner of ordering *Oyl*, and *Colours*, for painting *SUN-DIALS*.

Concluding with Tables ready calculated for all Latitudes and Declinations, for the more expeditious Drawing the Hour-lines upon any *Plain*.

By *HENRY WILSON*.

TO THE
READER.

MR. *Leybourn's Dialling* being known fo univerfally to be a ufeful practical Piece, we thought we could not better oblige the World with a Work of that Kind, than by revifing and improving what was of principal Ufe in it, and rendring it ufeful to all Capacities and Abilities ; in order to which, we have,

I. Corrected what was chiefly ufeful in the Theory and Practice of *Dialling*, in all its Varieties, and upon all Plains.

II. We have added what was wanting to make it compleat ; amongft which Ad-

ditions, are, 1. *Instrumental Dialling*, as
perform'd by the Lines of Hours, and In-
clinations, &c. upon the common Scales.
2. *Mechanick Dialling*, shewing how to
make a Dial upon any Plain, without
Mathematical Instruments, Trigonome-
trical Tables, or any Knowledge in the
Mathematicks. 3. The ordering of Oyl
and Colours for painting of Dials; toge-
ther with several Varieties, as making a
Dial to know the Hour of the Day at
any Part of the World, &c. These, with
other diverting Improvements, are added
in this, which were never in any Impres-
sion of *Leybourn's Dialling* before.

III. We have contracted the whole, by
reducing the Cuts, and engraving them
on *Copper-plates*, whereby the Book, (tho'
containing all the above-mentioned Ad-
ditions) will come cheaper than the
former Impression.

I know it is a common Objection,
that let a Book be never so plain, it is
impossible to learn any Science, (whether
Dialling, or any other) so well by a Book
as with a Master. I answer, that may in
some Measure be owing to a Want of
due Order and Application in reading
the Book; as for Instance, Suppose ha-
ving

ving this Book, and no Instructor, and it was required to make a *Horizontal Dial* in *Lead, Brass*, or *Stone*, turn to Page 37, and there you have such plain Instructions, as if follow'd, you cannot miscarry in your desired Success. Likewise, if it be required to make a *South Dial*, or a *Declining*, or *Reclining*, or *Inclining Dial, &c.* Look in the Table following, it will direct you to the Page, Chapter, and Section, where you have full Directions.

And because this Book may probably come into the Hands of some *Masons, Carpenters*, or the like, in the Country, that have not attained so much Mathematicks, as to qualify them for understanding these Directions, I have, for that Reason, inserted *Mechanick Dialling,* (Chap. 11. Page 215.) whereby any Person that can but read and write, may (by the Directions there given) make any Plain Dial, and perform the whole as well as they that have attained a greater Perfection in the Mathematicks.

I do not know of any Difficulty the Learner can be under, except in this, that having described the Hour-lines, &c. upon his Dial, yet there is not a Painter

pre-

present that understands the laying on of Colours in Oyl, so as to endure the Weather, and consequently be fit for painting of Dials.

To prevent, or rather anticipate this Objection also, I have given Directions for the ordering of Oyl and Colours for painting of Sun-Dials, (Page 254.) so that this Piece of *Dialling*, with all the above-mentioned Improvements, and others therein contained, and not here mentioned, I think, may, without Presumption, be recommended to the World, as the most perfect Compendium of *Dialling* now extant; and if it be said that Mr. *Good's Dialling* hath acquired the Name of a useful Book, it is easily proved, that it is in part only a Copy of this, as will appear, by comparing the two last Plates in *Good's Dialling*, with Plate 9 and 10 in this Impression of *Leybourn's Dialling*; and if an imperfect Copy, or Abstract, be of Use, I hope much more the Original, with those useful Additions with which it is now improv'd, by

A true Lover of the Mathematicks,

HENRY WILSON.

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GEOMETRICAL DIALLING.

ARITHMETICAL DIALLING.

A *Supplement* to Geometrical Dialling.

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BOOK

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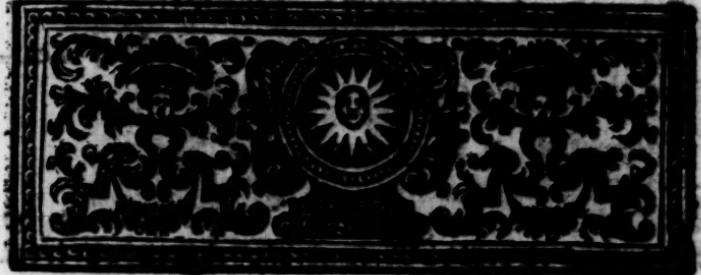
Geometrical Problems.

PROBLEM I.

Upon a Right Line given to erect a Perpendicular.

DEFINITION.

A Right Line is said to be perpendicular to another Line, when it maketh the Angles on either side of the erected Line equal, that is, so that the Line inclines not either to the Right or to the left, but standeth upright upon the Line upon which it is erected, as in *Plate* 1. *Fig.* 1. the right Line A B is said to be perpendicular to the Line C D, upon which it is erected, because the Angles on either side thereof are equal ; namely the Angle A B C on the one side, is equal to the Angle A B D, on the other side, and either of these Angles are called

B

Right Angles, and the Line A B so erected, is called the *Perpendicular.*

P R A C T I C E,

Let CD be a right Line given, and let it be required to erect a *Perpendicular* thereupon from the Point B : Open your Compasses to any convenient small Distance, and setting one Foot in the Point B, with the other, make *Plate* 1.   the other two Marks E and F, on either side of the Point B.—— This *Fig* 1.   done, open the Compasses to any other convenient Distance greater than the former, and setting one Foot in the Point E, with the other draw the obscure Arch G G, as near as you may guess over the given Point B. Again, (the Compasses being still opened to the same Distance) set one Foot in the Point P, and with the other Foot describe another obscure Arch H H, crossing the former in the Point A, so is A the Point, through which if you draw a right Line from the given Point B, that right Line A B so drawn, shall be perpendicular to the given Line C D, and from the Point B, as was required.

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P R O B L. II.

How upon (or near) the End of a given right Line, *to erect a* Perpendicular.

TO effect this, there are several Ways, but I will instance only in two, which are familiar and easy.

The

The First Way.

Let A B be a Line given, and from the Point A, which is towards the End thereof, let it be required to erect a Perpendicular A C.—— First open your Compasses *Plate* 1. to any small Distance, and setting one *Fig.* 2. Foot in the given Point A, with the other describe the Arch F E D, then set one Foot of the Compasses in D, (they being opened to the same Distance) cross the Arch. in E, and setting one Foot in E, with the other describe the Arch A F G crossing the first Arch in F.—— Again, set one Foot in F, and with the other describe the small Arch H H, crossing the former in the Point C: So the Line A C being drawn, it shall be perpendicular to the given Line A B, and from the Point A, as was required.

The Second Way.

Let B be the Point given, and from it let it be required to draw the Line B I, perpendicular to A B.—— Open the Compasses to any small Distance, and setting one Foot in the given Point B, pitch down the other Foot at all Adventures, as at K, so the one Foot being in K, turn the other Foot about till it cross the given Line A B in L, then through L and K draw the Line L K M, and set the same Distance K L, from K to M, so the Line B I drawn from B, through M, shall be perpendicular to A B, and from the given Point B, as was required.

B 2 PROB. III.

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PROBL. III.

How from a Point above to let fall a Perpendicular
to a right Line *given.*

IN this there are two Cases. First, when the
Point above is over (or near) the middle of
the Line. And Secondly, when the Point above
is near over the end of the Line.

The First Case.

Let R O be a right Line given, and from the
Point P, over it, let it be required to
Plate 1. let fall the Perpendicular P Q. ———
Fig. 3. First, open your Compasses to any
Distance greater than P Q, and set-
ting one Foot in the given Point P, with the
other describe an Arch of a Circle, cutting the
given Line N O, in the Points R S. Then, Se-
condly, divide the Space between R and S in
two equal Parts in Q. (by the fourth *Problem*
following) so a Line drawn from the given Point
P to Q, shall be perpendicular to the given Line
N O.

The Second Case.

Let V be the point given, from whence to let
fall a *Perpendicular* to the Line R O, ——— *First,*
from any part of the given Line R O, as from
T, draw a right Line to the given point V,
which Line (by the next *Problem*) divide into two
equal parts in the point X, with that Extent of
the Compasses (one Foot being placed in X)

with

with the other defcribe the Arch or Semicircle
V O T, cutting the given Line R O in O, a Line
drawn from V to O fhall be perpendicular to the
given Line R O, and towards the End thereof,
as was required.

PROBL. IV.

How to divide a right Line *given into two equal*
Parts.

LET the Line A B be a Line given, to be
divided into two equal parts at right Angles.
Take in your Compaffes the length of the Line
A B, or (if that be too long) any other Diftance
above half the length thereof, and fet-
ting one Foot in the End A, with the   *Plate* 1.
other draw the Arch C D E, (then the   *Fig.* 4.
Compaffes unaltered) fet one Foot in B,
and with the other Foot crofs the former Arch
(both above and below the Line) in the Points
F and G ; then a Ruler laid from F to G fhall
cut the given Line in H, fo fhall A B be divi-
ded into two equal parts in the Point H, which
was required.

PROBL. V.

A Right Line *being given how to draw another* right
Line, *which fhall be* Parallel *thereunto, at any Di-
ftance required, or through any Point affigned.*

DEFINITION

OF *Parallel Lines* there are principally two
kinds, *viz. Streight or Right Lined Parallels,*
and *Circular Parallels.* All Circles that are defcri-
ded or drawn upon the fame Centre, whether
they

B 3

they be greater or leffer one than the other, are
said to be *Parallel* or *Concentrick Circles,*
Plate 1. as the Circle A B C D, may be faid to
Fig. 5. be a *Concentrick Circle* with, or a *Parallel
Circle* to E F G H, becaufe both of
them are defcribed or drawn upon the fame Point
or Centre O ; and of both thefe Circles, the
right Line A C is the Diameter of the greater
Circle, and E G of the leffer, the Point O is
the Centre of both, and all right Lines drawn
from thence to the *Periphery, Circumference,* or *Limb*
of either of the Circles, are equal, and are fome-
times called the Semidiameters, and fometimes
the *Radius* of the Circle, as the Lines O C or O B
of the greater, and O H and O E of the leffer :
It containing 60 fuch Degrees or Parts, of which
the whole Circle contains 360.

But *Right Lined Parallels,* are fuch right Lines,
that being drawn upon the fame Plain, and in-
finitely extended on
either fide, would ne-
ver concur or meet,
but always in all parts,
retain an equal Di-
ftance, and fuch are the right Lines B C, and B D,
in the Margin.

In the defcribing or drawing of *Parallel Lines,*
there may fall out two Cafes or Varieties : As,

1. It may be required to draw a *Right Line
Parallel* to another *Right Line,* at a Di-
ftance given.

2. It may be required to draw the *Parallel
Line* through a Point affigned.

And of this kind there may be two Cafes ; For,

1. The given Point may be over or under
the given Line ; Or,

2. It may be Oblique to the given Line.

P R A.

PRACTICE.

Of the First Case.

Let E F be a right Line given, and let it be required to draw another right Line parallel thereunto, at the Distance of the Points G and H.

Take in your Compasses the giv- *Plate* 1. en Distance G H, then setting one *Fig.* 6. Foot of the Compasses in E, (or any other Point near the End of the given Line) describe a small obscure Arch of a Circle, as I K. Then moving the Compasses to F, (towards the other End of the given Line, (describe another obscure Arch as L M ; then lay a Ruler to the very Top of these two Arches, so that the Ruler do not cross, but just touch either of them : Then by the side of the Ruler draw the Line N O, and it shall be parallel to the given Line E F, and at the Distance G H, which was required.

The Second Case.

Let P Q be a right Line given, and let it be required to draw another right Line parallel thereunto, which shall pass through the Point R.

First, Set one Foot of your Compasses in the given Point R, and with the other take the nearest Distance to the given Line P Q, which is done by opening or shutting *Plate* 1. of the Compasses, till the moveable *Fig.* 7. Point do only touch the given Line P Q, describing the Arch s t. The Compasses still

ftill refting at this Diftance, fet one Foot in P,
(or any other Points to the End of the given
Line) and with the other Foot defcribe the
Arch u x. Laftly, By the very Top of this
Arch Y, draw the right Line Y R, and it fhall
be parallel to the given Line P Q, and fhall pafs
directly through the given Point R, which was
required.

The Third Cafe.

Let A B be a right Line given, and let it be
required to draw another right Line parallel
thereunto, which fhall pafs through the Point
C.

Take in your Compaffes the Diftance from
the given Point C, to the End of the
Plate 1.   given Line B, then fet one Foot in
Fig. 8.   A, the other End of the given Line,
and with the other Foot defcribe the
Arch f g. Again, Take in your Compaffes the
length of the given Line A B, and fetting one
Foot in C, with the other defcribe the Arch d e,
croffing the former Arch in the Point H, fo the
Line H C being drawn, fhall be parallel to the
Line A B, and fhall pafs through the given
Point C, as was required.

PROBL. VI.

*Any Three Points (which are not in a ftraight Line)
being given ; how to find the Centre of a Circle,
which fhall pafs through thofe three given Points.*

LET the three given Points be A B and C,
through which it is required a Circle fhould
be

be defcribed : Firft, Set one Foot of the Com-
paffes in one of the given Points as in A, and ex-
tend the other Foot to B, another of the Points,
and draw the Arch of a Circle G F D,
Secondly, The Compaffes not altered;   *Plate 1.*
fet one Foot in B, and with the other   *Fig. 9.*
crofs the former Arch with two fmall
Arches, In the Points D and E, and draw the
right Line D E. Thirdly, Set one Foot of the
Compaffes in the third Point C, (they ftill keep-
ing the fame Diftance) and with the other Foot
crofs the firft drawn Arch G F D, in the Points
F and G, and draw the right Line F G, croffing
the former right Line D E, in the point O. So
is O the Centre fought for ; upon which, if you
defcribe a Circle at the Diftance O A, it fhall
pafs through all the three given Points A B and
C, as was required.

PROBL. VII.

Two Points within a Circle being given, how to find
the Centre of a Circle, which being defcribed, fhall
pafs through the two given Points ; and fhall alfo
divide the Periphery or Circumference of the given
Circle into two equal Parts.

THIS and the foregoing Propofition, come
in continual Ufe and Practice throughout
this Work, and therefore ought more efpecially
to be minded.

Let the Circle given be A B C D, and the
two Points within the fame be E and F.

Firft, Through either of the given Points, (as
E,) draw a right Line B E D, which muft pafs
through

through the Centre of the given Circle at R.——
Secondly, draw the Line A C through the
Centre, and at right Angles to B E D——
Thirdly, From the given Point
Plate 1. E draw a right Line E A, and upon
Fig. 10. the End thereof A, (by the *2d Pro-*
blem) erect the Perpendicular A G,
crossing the Line B D, (it being extended) in the
Point G, so shall G be a third Point, and then
having the three Points E F and G, (by the last
Problem) you may find a Centre, upon which a
Circle being described, shall pass, whose Centre
will be at H, without the given Circle, upon
which point, if you describe the Arch of a Cir-
cle at the Extent or Distance of H E, H F, or
H G, it shall pass through the two given *Points*
E and F, and shall also divide the given Circle
A B C D, into two equal parts in the points M and
L, which was required. And that this Arch
thus drawn doth divide the given Circle into two
equal parts, is evident, for a Line drawn from
L to M, will pass directly through the Centre of
the given Circle, and shall therefore divide it in-
to two equal parts.

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PROBL. VIII.

How to make a Line of Chords *Geometrically, to*
any assigned Length or Radius.

FOrasmuch as through this whole Treatise,
there is continual Mention and Use made of
a *Line* of *Chords,* it will not be impertinent in
this place to discover the making thereof, for
the

the Convenience of fuch as at all times, and in all places, cannot have the Benefit of the *Mathematical Inftrument Maker*, to whom thefe things are common.

DEFINITION.

A Line of Chords is no other than 90 Degrees of the Arch of any Circle, transferred from the Limb of a Circle to a ftraight Line; now every Circle great or fmall, is divided (or fuppofed to be fo) into 360 equal parts, called *Degrees*, fo the Semicircle contains 180, the Quadrant 90, and the Radius or Semidiameter (which is that Line upon which the Circle or Semicircle is defcribed) noted in the following Figure with the Letters A B, is always equal to 60 Degrees of that Circle which it defcribes, and therefore 60 Degrees of a *Line* of *Chords* is called the *Radius* thereof. Thus much for the Definition of a *Line* of *Chords*, now for

CONCLUSION.

Firft, Draw a right Line of any length, as F B D, and near the Middle thereof, (by the firft or fourth *Problem*) erect the Perpendicular A B.

Secondly, Open your Compaffes to the Radius, or length that you would have your *Line* of *Chords* to be of, which fuppofe A B, and with that Diftance upon B, as a Centre, defcribe the Quadrant B A D.

Thirdly, Divide the Arch or Quadrant A R D, into 90 equal parts or Degrees, which you may do in this Manner. (Take the length of the Line A B, and fet that Diftance upon the Qua-
drant

drant A D, from D to R, so is D R 60 deg. and
A R 30 deg.   Then take the Distance A R, and
set it from D to S, so is the Quadrant divided
into three equal parts, at the Points S and R,
each containing 30 deg.   This done, divide the
several Spaces between A R, R S, and S D, into
3 equal parts, each of which will be 10 deg. ac-
cording as you see the Numbers set to them,
these must be again divided into two equal parts,
each part containing 5 deg. and every of those
into five smaller, as you see in the Figure, and
so will the whole Quadrant be divided into
90.)

Fourthly, The Quadrant A R S D being thus
divided into 90 parts or degrees, set one Foot
of your Compasses in D, and open the other Foot
to A, and describe the Arch A E F, touching the
Line F D in F, so is D F upon the right Line F
D, the *Chord* of 90 deg.

Fifthly, Open the Compasses from D to 80
deg. and describe the Arch 80 G H,
Plate 1.   so shall H be the *Chord* of 80 deg.
Fig. 11.   Sixthly, Open the Compasses
from D to 70, and describe the Arch
70 I K, so is D K the *Chord* of 70 deg.

Again, Open the Compasses from D to R, the
Radius, or 60 deg. and describe the Arch R L B,
so is D B the *Chord* of 60 deg. equal to the Ra-
dius.

Do the like with 50, 40, 30, 20, and 10 deg.
So shall you have the Line D F divided into 90
unequal parts, called *Chords.*

In this Manner may you make a *Line* of *Chords*
of any length, and set it upon a Ruler, and it is
fit to perform all the Uses in this Book; and it
were convenient that upon one and the same Ru-
ler, you had three, four, or five *Chords* of seve-
ral

ral Lengths or Radius's, or a Sector, which answers the same End, as in Practice you will find to be necessary and commodious.

Being thus provided of a Line of Chords, I will now shew you how to work two Conclusions Geometrically, which are of absolute Use in Dialling, *the one is to find the Hour of the Day, and the other to find the Azimuth of the Sun at any Time, and in any Place. And with them I shall conclude these Geometrical and Astronomical Elements.*

B   *ASTRO-*

ASTRONOMY.

FOR the better underſtanding of that which followeth, the Reader ought to be acquainted with the principal Circles of the Sphere ; as, alſo with ſuch other Lines and Points, as are deſcribed and noted upon the Material Sphere or Globe, in Imitation of thoſe which are imagined to be in the Heavens. And of ſo many of theſe, as are neceſſary for this our preſent purpoſe, I ſhall give you a brief Account.

DEFINITIONS.

A *Sphere* or *Globe* is a ſolid Body, containing only one Superficies, in whoſe Middle there is a Point, from whence all right Lines drawn to this Superficies are equal.

The principal Circles of which a Sphere or Globe is compoſed, are in Number Ten ; whereof ſix are great, and four are ſmaller Circles.

A great Circle is that which divideth the Body of the Globe into two equal Parts or Hemiſpheres. A ſmall Circle is that which divideth the Globe into two unequal parts.

The

The six great Circles are,

1. The *Horizon,*   4 The *Ecliptick,*
2. The *Meridian,*   5 } The two *Colures.*
3. The *Æquinoctial,*   6 }

The lesser Circles are.

1. The *Tropick* of *Cancer,*   3. The *Artick* Circle.
2. The *Tropick* of *Capricorn.*   4. The *Antartick* Circle.

Of these in the Art of Dialling there are principally but five to be taken Notice of, *viz.* three great Circles, and two smaller Circles.

The Great Circles are,

1. The *Horizon,*
2. The *Meridian,*
3. The *Æquinoctial.*

The Lesser Circles are,

1. The *Tropick* of *Cancer,*
2. The *Tropick* of *Capricorn.*

Of the HORIZON.

In the Figure, let the outermost Circle thereof, noted with the Letters H Z O N, represent a Sphere or Globe, then the Horizon is a Circle which divideth or separateth the visible Part of the Heavens which we see,

Plate 1.
Fig. 12.

from

from the invisible part which we see not, and
is represented in the following Figure by the
Line (which represents a great Circle) H Q O,
separating the visible Hemisphere H Z O, which
we see ; from the invisible part thereof H N O,
which we see not.

Of the Meridian.

The Meridian is a great Circle of the
Sphere which passeth by the Poles of the
World, and through the Zenith
Plate 1.   and Nadir of the Place. To this
Fig. 12.   Circle when the sun cometh, he be-
ing above our Horizon, maketh
Noon or Mid-day, and being in the same Cir-
cle, when it is under the Horizon, it is then
Midnight.

The Zenith is that point in the Heavens
which is directly over your Head, in what part
of the World soever you be. And,

The *Nadir* is that Point in the Heavens which
is under our Feet, directly opposite to the Ze-
nith.

The *Meridian Circle* in this Figure, is noted
with the Letters H Z O N, the Point Z at the
Top representing the *Zenith,* and N the *Nadir*
Points.

III. Of the Æquinoctial.

The *Æquinoctial* is a great Circle of the Sphere,
dividing it into the Northern and Southern He-
mispheres, which take their Names from the
two Poles, that being called the *Northern Hemi-
sphere,* in which the *North Pole* is seated, and that
the *Southern,* in which the *South Pole* is seated
Unto

Unto this Circle when the Sun in his annual Motion arriveth (which is but twice in the whole Year) the Days and Nights are of equal Length through the whole World.

This Circle cutteth the Axis of the World at right Angles, and is seated in the Heavens 90 deg. or a Quarter of a Circle, distant from either of the Poles.

It is represented in this Figure by the Line or Circle Æ Q æ. The two Poles are noted with P and S ; P being the *North*, and S the *South Pole* ; and so the Hemiphere æ P Æ, is the *Northern*, and Æ S æ the *Southern Hemisphere*. And the right Line P Q S is the *Axis of the World*, crossing the *Æquinoctial* at right Angles in Q, the Centre, or middle Point of the *Sphere* or *Globe*.

IV. *Of the two* Tropicks.

The two *Tropicks* are smaller Circles of the Sphere, described parallel to the Æquinoctial Circle, and at 23 deg. and a half distant therefrom ; that being the greatest Declination that the Sun hath from the Æquinoctial towards either of the Poles. Of these Circles one is called the *Tropick* of *Cancer*, or Northern Tropick ; the other the *Tropick* of *Capricorn*, or Southern Tropick, so denominated from the *Poles* which they respect or behold. As the Tropick of Cancer, marked with the Character of *Cancer*, ♋ ♋ at each End thereof, beholdeth P, the *North Pole*, and the Tropick of Capricorn, noted with the Characters of *Capricorn*, ♑ ♑ at each End thereof, respecteth S, the *South Pole*.

These two Circles are the Bounds or Limits of the Sun's Course, for between them he always moveth, never going more Northward or South-

ward, (that is, declines not nearer to either of the
Poles) than 23 deg. 30 min. Where-
fore, when the Sun in his annual
Course shall arrive to the Tropick of
Cancer, which is about the 10th of
June, he maketh the *Longest Days* to all that in-
habit in the Northern Hemisphere. And when
he arriveth to the Tropick of *Capricorn*, which
is about the 11th of *December*, he maketh the
Shortest Days to those that inhabit the Northern,
and the *Longest* to those of the Southern Hemi-
sphere.

Besides those Circles here named, there are divers others
described upon the Globe, two Sorts whereof are of
great Use in Dialling.

Hour Circles, and Azimuths.

HOUR *Circles* are great Circles of the Sphere,
which meet together in the *Poles* of the
World, and cross the Æquinoctial at Right An-
gles, of which the Meridian (or outward Circle
in this Figure) is the Hour Circle of 12, the
streight Line P Q S, which represents the Axis
of the World, is also the Hour Circle of Six,
and all the rest of the Hour Circles are drawn
from *Pole* to *Pole* between them, as the Circle P
A S represents an Hour Circle, and so of all the
rest, which are 12 in Number, representing the
24 Hours of the Day and Night being taken
round the Globe or Sphere.

Azimuths are also great Circles of the Sphere,
meeting together in the *Zenith* and *Nadir* Points,
and fall upon, or intersect the Horizon at right
Angles; as the Hour Circles do the Equinoctial.
Of

Of thefe Circles, the outermoft Circle of this Figure reprefents the North and South Azimuth; and the Line Z Q N the Azimuth of Eaft and Weft, and is commonly called the *Prime Vertical Circle.* And all other Circles drawn through the *Zenith* and *Nadir* Points, and cutting the Horizon at right Angles, are intermediate Azimuths between the Eaft and Weft, or the North and South Points. As in *Plate* 1. *Fig.* 12. the Circle Z B N is an intermediate Azimuth between the South and the Weft.

Every Circle of the Sphere hath its proper *Poles,* which are always 90 deg. diftant from it in all parts.

So in the former Figure Z the *Zenith,* and N the *Nadir* Points, are the *Poles* of the Horizon, they being 90 deg. diftant from O the South Point, from Q the Weft Point, and from H the North Point of the Horizon.

Alfo Q is the Pole of the Meridian Circle H Z O N, it being 90 deg. diftant therefrom in all parts.

Again, P and S, the North and South *Poles* of the World, are alfo the *Poles* of the Equino&ial Circle, they being removed therefrom on either fide 90 deg.

But the *Pole* of the Hour-circle P A S is at C, and the *Pole* of the Azimuth Circle Z B N is at D, and how to find thefe *Poles,* and alfo the *Poles* of any Oblique Circles, fhall be difcover'd in diverfe places of the following Difcourfe, where there is often Occafion for the finding of them.

Note. *And whereas throughout this Book there is continual Mention made of Degrees and Minutes, know, that a Degree is the 360th Part of any Circle, each of which Degrees is fuppofed to be divided*

vided into 60 Parts called *Minutes, so* that 45 *min.* is *three quarters of a Degree,* 30 *min.* half *a Degree, and* 15 *min.* one *quarter of a Degree,* &c.

These are such *Astronomical Elements,* as I conceive, most necessary for the understanding that which follows;

It resteth now, that I shew how to perform two or three *Astronomical Conclusions* Geometrically, without which the Knowledge of making of a Dial will be of little Validity; for to what purpose will a Dial serve without it be rightly placed? Or how can you make a Dial for any appointed place, without you first know the Position or Situation thereof? And to these purposes are the following Conclusions subservient.

And because it is requisite to know at all Times of the Year, what Declination the Sun hath from the Æquinoctial either Northward or Southward, I have therefore at the End of this Introduction, inserted two Tables, the one shewing the Sun's Declination every Day in the Year. And the other, a Table shewing the Latitudes of all the Principal Cities and Towns in England, Scotland, *and* Ireland.

PROB

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PROBL. IX.

Having the Latitude of the Place, the Altitude of the Sun, and the Day of the Month given, to find the Hour of the Day, and Azimuth of the Sun.

LET the place be *London*, whose Latitude is 51 deg. 32 min.——— Let the Sun's Altitude be 45 deg——— And let the Day of the Month be the 11th of *May*, at which Time, by the following Table, the Sun's Declination is 20 deg. 20 min. North.

First, Describe the Circle H Z O N, representing the Meridian of the Place;——— Cross it at right Angles with the two Diameters H Q O, for the Horizon, and Z Q N for the *Prime Vertical* Circle, or *Azimuth* of East and West.

Secondly, Take 51 deg. 32 min. the Latitude of the Place, out of your Line of Chords, and set it from H to P in the North, and from O to S the South Pole; and draw the line P Q S, for the Axis of the World. And because the Æquinoctial Circle is in all parts distant from the *Poles* of the World 90 deg. take 90 deg. of your Chord, and set them from P to Æ, and from S to æ, and draw the Line Æ Q æ for the Æquinoctial Circle.

Thirdly, The Sun's Altitude given being 45 deg. Take 45 deg. from your Chord, and set them from H to A, and from O to T; and lay a Ruler either from H to T, or from O to A, and the Ruler will cross the *Prime Vertical* Circle in L, through which point the Circle of the Sun's Altitude must be drawn; and for the drawing of it you have three points A L and

and T, wherefore by the 6th *Problem* before-going you may find its Centre, which will always be in the *Prime Vertical* Circle Z Q N extended.

Fourthly, The Sun's Declination for the Day proposed, (*viz.* the 11th of *May*) being 20 deg. 20 min. Northward, therefore take 20 deg. 20 min. out of your Line of Chords, and set them from Æ to C, and from æ to D, towards P the North *Pole*, because the Declination was North, otherwise it should have been set towards S the South *Pole*. Then laying a Ruler either from Æ to D, or from æ to C, it will in both Cases cut the Axis of the World in E, through which point the Parallel of the Sun's Declination for that Day must be described, and for the drawing of it, you have three points, D, E, and C, whose Centre will always be in the Axis of the World S Q P extended, and may be found by the former 6th *Problem*.

Fifthly, Observe in your Scheme, where the Parallel of Altitude A L T, and the *Plate* 1. Parallel of Declination D E C, do *Fig.* 13. cross each other, which will be at the point ☉, and that is the place of the Sun at the Time of the Question.

Sixthly, By the fore-mention'd 6th *Problem*, draw an Hour-circle through the three points P ☉ and S, whose Centre will always be in the Æquinoctial Line extended, if Need be; also through the Points Z ☉ and N, draw an Azimuth Circle, whose Centre will always be in the Horizon extended when need requires.

These two Circles being thus drawn, your Scheme is prepared for the finding both of the Hour and Azimuth in this manner.

I. *For*

I. For the HOUR.

Lay a Ruler to P, the *Pole* of the World, and G the point where the Hour-circle croſſeth the Æquinoctial, and the Ruler will cut the Circle in *a*. So the Diſtance from *a* to *Æ* being meaſured upon the Line of Chords, will be found to contain 41 deg. 48 min. which is the Hour of the Day, counted from Noon, which reduced into Time (by allowing 15 deg. to an Hour, and 1 deg. to 4 minutes of Time) will be 2 Hours 47 Minutes, that is, either 47 Minutes after 2 in the Afternoon, or 13 Minutes after 9 in the Forenoon.

II. For the Azimuth.

Lay a Ruler to Z the Zenith, and to B the point where the Azimuth Circle croſſeth the Horizon, and the Ruler will cut the Meridian Circle in the point *b*, ſo the Diſtance *b* O being meaſured upon the Line of Chords, will be found to contain 62 deg. 8 min. And ſuch is the Sun's Azimuth from the South Part of the Meridian.—— Or the Diſtance N *b* being meaſured upon the Chords, will be found to contain 27 deg. 52 min. which is the Sun's Diſtance or Azimuth from either Eaſt or Weſt, according to the Time of the Day.

Thus by one and the ſame Projection of the Sphere, you have found both the Hour and the Azimuth, and many other Concluſions Aſtronomical might be wrought by this way of Projection, which I have more fully ſhewed in my *Geometrical Exerciſes*. But ſeeing

ing that the *Azimuth* is of such frequent use in Dialling, that nothing can be done to purpose without it, and that in this Way of Projection, sometimes the Centres of the Circles will be very remote, I will here shew you another Geometrical Way, whereby you may find the *Azimuth* at any Time, and in any Place, by streight Lines, which will be some Light and Ease to the Practitioner, that so he may compare one Way with the other in case of any Doubt, which will be a good Confirmation of his Work.

Another Way to find the Azimuth.

LET the given Latitude be 51 deg. 32 min. The Declination North, 20 deg.

The Sun's Altitude 40 deg.

And let the Sun's Azimuth be required.

First, Upon the Centre Q, describe the Semicircle H Z O for half the Meridian, and upon Q, raise the Perpendicular Q Z.

Plate 1.
Fig. 14.

Secondly, Set (by the Help of your Line of Chords) 51 deg, 32 Min. the Latitude of the Place, from Z to Æ, and draw Æ Q for the Æquinoctial.

Thirdly, Set 20 deg. the Sun's Declination, from Æ towards Z, to the Point D, (being it is North) and draw the Line D T parallel to Æ Q, so is D B T the Parallel of the Sun's Declination.

Fourthly, Set 40 deg. the Sun's Altitude given, from O to L, and from H to M, and draw the Line M S L, for the Parallel of Altitude.

Fifthly,

Fifthly, Take in your Compasses half the Length of the Parallel of Altitude S L, or S M, and with that Distance upon Q, describe the innermost Semicircle.

Sixthly, Through the Point B, which is where the Parallel of Declination, and the Parallel of Altitude do intersect, erect the Perpendicular R C, till it touch the innermost Semicircle at C.

Lastly, Lay a Ruler from Q to C, and it will cut the outermost Circle in E, so shall H E measured upon the Line of Chords, be 109 deg. 47 min. the Sun's Azimuth from the North part of the Meridian.

E Z shall be 19 deg. 47 min. the Azimuth from East or West. And,

E O shall be 70 deg. 13 min. the Azimuth from the South part of the Meridian.

Having made this fair Preparative, I will here insert the two fore-mentioned necessary Tables of the Sun's Declination, and Latitudes of Places; and then proceed to the Art of Dialling, the thing chiefly in this Place intended.

D

A Table of the Sun's Declination.

Days	Januar.		Febr.		March		April		May		June	
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.
1	21	44	13	46	3	24	8	36	18	5	23	12
2	21	33	13	26	3	0	8	58	18	20	23	16
3	21	23	13	5	2	37	9	20	18	35	23	19
4	21	13	12	45	2	13	9	42	18	50	23	22
5	21	2	12	25	1	49	10	3	19	4	23	24
6	20	50	12	4	1	25	10	24	19	18	23	26
7	20	38	11	43	1	1	10	45	19	31	23	28
8	20	26	11	21	0	38	11	0	19	44	23	29
9	20	13	11	0	0	14	11	27	19	57	23	30
10	20	0	10	38	0	10	11	47	20	10	23	30
11	19	46	10	16	0	33	12	7	20	22	23	30
12	19	32	9	54	0	57	12	28	20	34	23	30
13	19	18	9	32	1	21	12	48	20	45	23	29
14	19	3	9	10	1	44	13	7	20	56	23	28
15	18	48	8	48	2	8	13	27	21	7	23	27
16	18	32	8	25	2	31	13	46	21	17	23	25
17	18	17	8	3	2	54	14	5	21	27	23	23
18	18	2	7	40	3	18	14	24	21	37	23	20
19	17	45	7	17	3	41	14	42	21	46	23	17
20	17	28	6	54	4	5	15	1	21	55	23	14
21	17	11	6	31	4	28	15	19	22	4	23	10
22	16	54	6	8	4	51	15	37	22	12	23	6
23	16	36	5	45	5	14	15	54	22	20	23	1
24	16	18	5	21	5	37	16	12	22	27	22	55
25	16	0	4	58	6	0	16	29	22	34	22	50
26	15	42	4	34	6	22	16	46	22	41	22	44
27	15	23	4	11	6	45	17	2	22	47	22	37
28	15	4	3	47	7	7	17	18	22	53	22	31
29	14	45			7	30	17	34	22	58	22	23
30	14	26			7	52	17	50	23	3	22	16
31	14	6			8	14			23	8		

South

North

A

A Table of the Sun's Declination.

days	July d.	m.	August d.	m.	Sept. d.	m.	Octob. d.	m.	Novem. d.	m.	Decem. d.	m.
1	22	8	15	12	4	24	7	15	17	40	23	9
2	22	0	14	54	4	2	7	38	17	56	23	13
3	21	51	14	36	3	38	8	0	18	12	23	17
4	21	42	14	17	3	15	8	22	18	28	23	20
5	21	32	13	58	2	52	8	45	18	45	23	23
6	21	22	13	39	2	29	9	7	18	58	23	25
7	21	12	13	20	2	5	9	29	19	13	23	27
8	21	2	13	1	1	42	9	51	19	27	23	29
9	20	51	12	41	1	19	10	13	19	41	22	29
10	20	40	12	21	0	55	10	35	19	55	23	30
11	20	28	12	1	0	32	10	56	20	8	23	30
12	20	16	11	41	0	8	11	18	20	21	23	29
13	20	4	11	21	0	16	11	39	20	34	23	28
14	19	51	11	0	0	39	12	0	20	46	23	27
15	19	38	10	39	1	3	12	21	20	58	23	25
16	19	25	10	18	1	26	12	41	21	9	23	22
17	19	12	9	57	1	50	13	2	21	20	23	19
18	18	58	9	36	2	13	13	22	21	31	23	16
19	18	43	9	15	2	37	13	42	21	41	23	12
20	18	29	8	53	3	0	14	2	21	50	23	7
21	18	14	8	31	3	25	14	21	22	0	23	2
22	17	59	8	9	3	47	14	41	22	9	22	57
23	17	44	7	47	4	10	15	0	22	17	22	51
24	17	28	7	25	4	33	15	19	22	15	22	44
25	17	12	7	3	4	57	15	37	22	33	22	37
26	16	56	6	41	5	20	15	55	22	40	22	30
27	16	39	6	18	5	43	16	1	22	46	22	22
28	16	22	5	56	6	6	16	3	22	52	22	14
29	16	6	5	33	6	29	16	49	22	58	22	5
30	15	48	5	10	6	52	17	6	23	4	21	56
31	15	30	4	47			17	28			21	

North South

A TABLE of the Names and Latitudes of the Cities, Towns, and Islands in and about Great Britain and Ireland.

England.	D.	M.	England	D.	M.
BEdford	52	8	London	51	32
Berwick	55	50	Northampton	52	14
Bristol	51	27	Norwich	52	41
Buckingham	52	0	Nottingham	53	0
Cambridge	52	12	Oxford	51	46
Canterbury	51	17	Reading	51	28
Carlisle	55	0	Salisbury	51	4
Chichester	50	48	Shrewsbury	52	47
Chester	53	16	Stafford	52	52
Colchester	51	58	Stamford	52	38
Derby	52	58	Truero	50	30
Dorchester	50	40	Warwick	52	20
Durham	54	50	Winchester	51	3
Excester	50	43	Worcester	52	14
Guilford	51	12	York	53	58
Gloucester	51	53			
Hertford	51	49			
Hereford	52	7	Wales.	D.	M.
Huntington	52	19	ANglesey	53	28
Ipswich	52	8	Barmonth	52	50
Kendal	54	23	Brecknock	52	1
Lancaster	54	10	Cardigan	52	12
Leicester	52	40	Carmarthen	51	56
Lincoln	53	14	Carnarvan	53	16

Den-

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Plate 1.

Fig. 11

Fig. 12

Fig. 13

Fig. 14
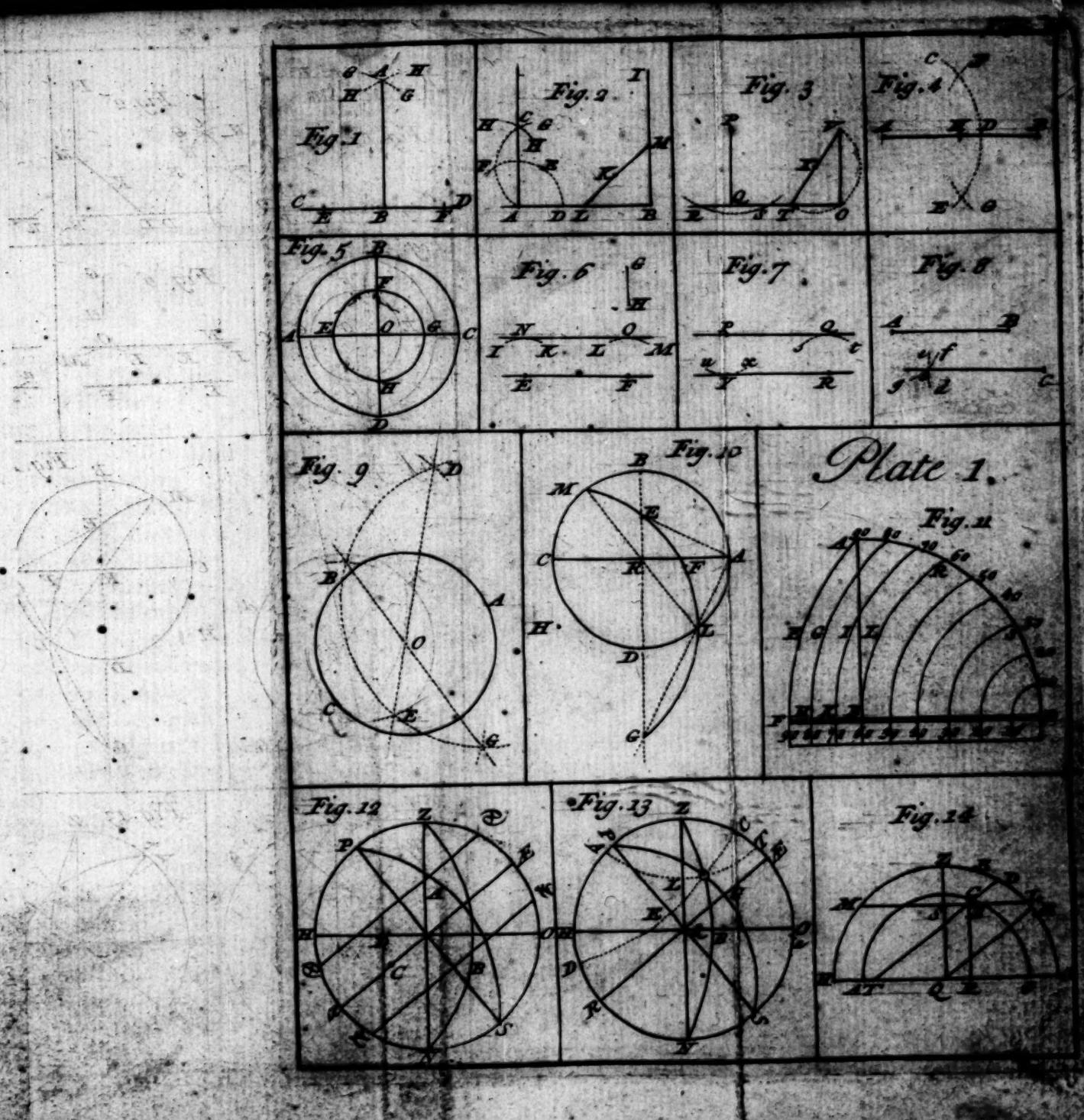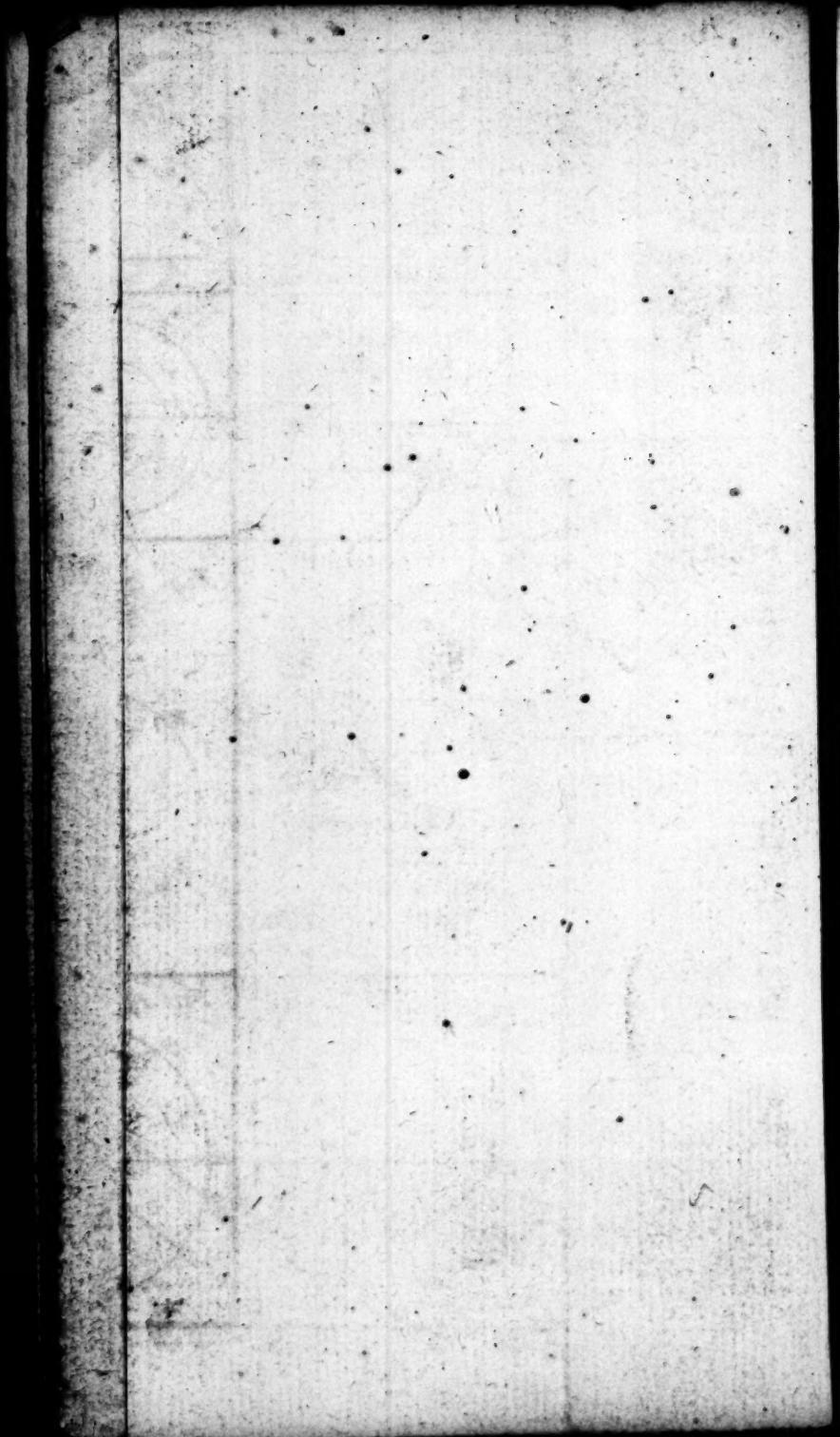
Wales.	D.	M.	Scotland.	D.	M.
Denbigh	53	13	St. Andrews	56	39
Flint	53	17	Skynaffin	58	36
Landaff	51	35	Stirling	56	12
Monmouth	51	51			
Montgomery	51	56			
Pembroke	51	46	Ireland	D.	M.
Radnor	52	19	A Ntrim	54	48
St. Davids	52	0	Arglas	54	10
			Armagh	54	14
			Caterlagh	52	41
Islands	D.	M.	Clare	52	34
G uernsey	49	30	Corke	51	50
Jersey	49	12	Droghedagh	53	38
Lundy	51	22	Dublin	53	20
Man	54	24	Dundalke	53	52
Portland	50	30	Galloway	53	2
Wight	50	39	Youghall	51	53
			Kenny	52	27
			Kildare	53	0
Scotland.	D.	M.	King's Town	53	8
A Berdeen	57	32	Knockfergus	54	57
Dunblain	56	21	Kingsale	51	31
Dunkel	56	48	Lymerick	52	23
Edinburgh	55	57	Queen's Town	52	52
Glasgow	55	53	Waterford	52	9
Kinsale	57	44	Wexford	52	13
Orkney	59	56			

The ART of
DIALLING

Geometrically perform'd,

By Projecting the *Circles* of the *Sphere* upon the *Plain* it self.

The First Part.

CHAP. I.

Of the several Sorts of Plains *upon which* DIALS *are usually made.*

DIALS may be made upon any plain Superficies, and all plain Superficies are posited in one or other of these three Positions; *viz.* either *Parallel*, *Perpendicular*, or *Oblique* to the Horizon of the Place wherein the Plain is seated, and all the Hour-lines drawn upon any Plain, are great

great Circles of the Sphere, which being pro-
jected upon a plain Superficies, become straight
Lines.

Now the Art of Dialling consisteth chiefly in
the finding out of these Lines, and their true Di-
stances each from the other, which do continu-
ally vary, according as the Plains upon which
they are described or projected, are situated in
respect of the Horizon of the Place.

Of these Plains there are but three Vari-
eties, *viz.*

1. *Parallel* to the Horizon, as is the *Horizontal*
(which I call *Vertical*) Plain only.

2. *Perpendicular* ⎞ which ⎧ Direct ⎧ North & South
to the *Horizon,* ⎬ be ⎨ As ⎨
and such are all ⎬ either ⎨ ⎨ *East* and *West*
erect Plains. ⎠ ⎩ Or *Declining.*

3. *Reclining* ⎞ ⎧ ⎧ North ⎫
from the ⎬ and these ⎨ Direct ⎨ South ⎬ Reclining
zenith, or ⎬ are either ⎨ ⎨ East ⎬ Inclining.
Inclining ⎬ ⎩ ⎩ West ⎭
to the *Ho-* ⎬ ⎧ Or
rizon. ⎠ ⎨ ⎧ Reclining
⎩ Declining ⎨
⎩ Inclining

Now in the making of particular Dials, which
are in Number 25, I reduce them to 17, by sup-
plying the *Inclining Plains* from their opposite *Re-
cliners,* as being indeed the same.

And to avoid Mistakes, which may possibly
arise by comparing my Examples, with other
Authors, or others with mine. You are to take

Notice

Notice, that I denominate all my *Plains* from the Sight (or the Positions) of their *Axis* in the Heavens, and not from the Circles of the Sphere in which they lie : Therefore take Notice, That

Those Plains which most Writers call

Horizontall
Vertical
Meridian
Equinoctial
Polar

} I call {

Vertical

North ⎰
South ⎱ Direct

East ⎰
West ⎱ Direct

Poles

Equinoctial

Because their Poles do lie in the

Vertex or Zenith Point.

North ⎰
South ⎱ Points of the Horizon.

East ⎰
West ⎱ Points of the Horizon.

Poles of the World.

Equinoctial Circle,

Again

Again, All leaning Plains, whether Direct or
declining, whose upper Faces behold the *Ze-*
nith, I call *Recliners;* and the nether, or under
faces of them, which respect, or look down to
the *Nadir,* I call *Incliners.*

This Distinction being made, the Plains
of all which Examples following, are
thus denominated.

1. *Vertical* or *Horizontal.*
2. *South* and *North* Direct.
3. *East* and *West* Direct.

4. *South* and *North,* declining { *East*
Or,
West.

5. *East* and *West* Direct { *Reclining.*
Or,
Inclining.

6. *Equinoctial,* Or, *South* Reclining or Incli-
ning to the *Pole.*

7. } *South* Direct Recli- { less } than the
8. } ning or Inclining { more } *Pole.*

9. *Polar,* Or *North* Reclining or Inclining to
the *Equinoctial.*

10. } *North* Direct Recli- { less } than the E-
11. } ning or Inclining { more } *quinoctial.*

12. *Equinoctial,* Or *South* Declining *East* or *West*
Reclining to the *Pole.*

13. } *South* declining *East* { above } the *Pole.*
or *West* Reclining
14. } or Inclining. { under }

15. *Polar* or *North* declining *East* or *West,* Re-
clining or Inclining to the Equator.

16. } *North* declining *East* { above } the Interse-
or *West* Reclining { ction of the
17. } or Inclining. { under } Meridian &
Equator.

The

Thus are the several Plains denominated, I shall now shew how the Situation of any Plain may be attained, either in respect of its Declination or Reclination.

CHAP. II.

How to find the Reclination *and* Declination *of any Plain.*

I. *For the* Reclination.

THE *Reclination* of a Plain, is the Arch of that Vertical Circle or Azimuth, which is perpendicular to the Reclining Plain, or that Azimuth, in which the *Pole* of the Reclining Plain lieth, comprehended between the Zenith of the Place, and the Reclining Plain.

To find which, let A B C D be a *Reclining Plain,* draw first thereon by the Help of a Ruler and Quadrant, a Line G H parallel to the *Horizon* of the Place, which shall be the Horizontal Line *Plate* 2. *Fig.* 1. of the Plain, and cross at it right Angles with another right Line K S, for the Vertical Line of the Plain ; to this Vertical Line K S, apply a streight Ruler K I, and to that End of it which lieth clear of the Plain as I, apply a Quadrant as O L I ; having a Thread or Plummet hanging from the Centre at I, then see what Number of Degrees of the Quadrant are contained between O and L, for so much doth the Plain recline from the *Zenith.*

II. *For*

II. *For the* Declination.

The Declination of a *Plain*, is an Arch of the
Horizon comprehended between the *Pole* of the
Plain, and the *Meridian* of the *Place*. Or it is
the Diftance of the *Plain* itfelf, from the prime
Vertical Circle, or Azimuth of *Eaft* and *Weft*.

To find out the Declination of any *Plain*, there
are required two Obfervations to be made by the
Sun at the fame Inftant of Time. The firft of
the Horizontal Diftance of the Sun from the
Pole of the *Plain*. And fecondly, Of the Sun's
Altitude.

1. To find the Sun's *Horizontal Diftance* from
the *Pole* of the *Plain*. Apply one Edge of a
Quadrant to the Horizontal Line of your *Plain*,
fo that the other may be perpendicular to it, and
the Limb of the Quadrant may be towards the
Sun, and hold the whole Quadrant Horizontal
(as near as you can conjecture.) Then holding
up a Thread and Plummet at full Liberty, fo
that the Shadow of the Thread may pafs both
through the Centre and Limb of the Quadrant,
obferve then the Degrees cut by the Shadow of
the Thread, and number them from that Side
of the Quadrant that ftandeth fquare or per-
pendicular to the *Plain*: For thofe Degrees are
the Horizontal Diftance required.

2. This Horizontal Diftance and the Sun's
Altitude being obferved at the fame Time, (as
near as may be) will help you to the *Plain's*
Declination by the Rules following.

Firft, By having the Altitude, you may find
the Azimuth by the two laft *Problems* of the
Introduction, then by comparing the Azimuth

<div align="right">and</div>

and this Diſtance together, you may find the *Plain's* Declination in this Manner.

When you make your Obſervations of the Sun's *Horizontal Diſtance*, mark whether the Shadow of the Thread fall between the *South,* and that ſide of the Quadrant which is perpendicular to the *Plain.*

1. If the Shadow fall between them, the *Azimuth* and *Diſtance* added together, do make the *Declination* of the *Plain*, and in this Caſe the *Declination* is upon the ſame Coaſt whereon the Sun's *Azimuth* is.

2. If the Shadow fall not between them, then the Difference between the Diſtance and *Azimuth* is the *Plain's* Declination; and if the *Azimuth* be the greater of the two, then the *Plain* declines to the ſame Coaſt whereon the Sun is; but if the Diſtance be the greater, then the *Plain* declines to the contrary Coaſt.

And here note, that the *Declination* thus found is always accounted from the *South,* and that all *Declinations* are counted from either *South* or *North*, towards either *Eaſt* or *Weſt,* and muſt never exceed 90 Degrees.

1. If therefore the Degrees of *Declination* from the *South* do exceed 90, you muſt take the Reſidue of that Number to 180, and that ſhall be the *Plain's* Declination from the *North.*

2. If the Degrees of Declination exceed 180, then the Exceſs above 180 Degrees gives the *Plain's* Declination from the North towards that Coaſt, which is contrary to the Coaſt whereon the Sun is.

Of *Vertical Dialling.*

CHAP. III.

How to draw the Hour-Lines upon a Vertical (com-
monly called Horizontal *) Plain.*

Example, Of *a* Vertical or Horizontal *Plain in the*
Latitude of London, *which is* 51 *deg.* 32 *min.*

FIRST, Draw a Circle E S W N, which
Circle let reprefent your Vertical Plain ; crofs
it in the Middle thereof at right Angles with the
two Diameters, *viz.* S Q N, fo: the Meridian,
and Hour-line of 12, and E Q W for the prime
Vertical or Hour line of 6.

Secondly, Becaufe the Latitude of the Place
is 51 deg. 32 min. take 51 deg. 32 min. out of
your Line of Chords, and fet that Diftance from
S to *a*, and from W to *b*.

Thirdly, Lay a Ruler from E to *a*, and it will
cut the Meridian Line S N, in the point P,
which point P is the *Pole* of the World : And a
Ruler laid from E to *b*, will cut the Meridian
in the point Æ fo is Æ the point where the
Æquinoctial croffeth the Meridian ; and thus
have you three points, viz. E, Æ, and W,
through which you muft draw the Æquinoctial
Circle E Æ W, whofe Cen-
ter will always be in the Me-   *A Vertical or Ho-*
ridian S N. So that you   *rizontal Dial for the*
may eafily find it, as hath   *Latitude of* Lon-
been before taught, and in   don, 51 deg. 32
this manner alfo. Draw the   min. *Pla.* 2. *Fig.* 2.
Line Æ W, which divide in

E   two

two equal parts in the point A, upon which point A, raise the Perpendicular A C, cutting the Meridian S N, in the point C, which is the Center of the Æquinoctial Circle E Æ W, upon which point, and the Distance C Æ, you may describe it.

Fourthly, Divide the Semicircle E N W, into 12 equal parts at the points ☉ ☉ ☉, &c. beginning at the point N, and setting 6 on either side thereof. The Semicircle may easily be divided into 12 parts in this Manner; for 60 deg. of the Line of Chords will divide it into three equal parts, and 30 deg. will divide each of them into two, that is, into 6 equal parts, and 15 deg. is the half thereof, which is a twelfth part of the Semicircle.

Fifthly, Lay a Ruler to Q, the Center of the Plain, and upon every of these Points ☉ ☉ ☉, and the Ruler will cut the Æquinoctial E Æ W, in the points * * * &c. dividing that into 12 unequal parts.

Sixthly, A Ruler laid to P, the *Pole* of the World, and the several points * * *, &c. upon the Æquinoctial, will cut the Circle representing the *Plain* in the points | | |, &c. dividing the Semicircle E N W, in 12 other unequal parts.

Lastly, From the point Q, and through the several points | | |, &c. draw straight Lines, as Q | 7, Q | 8, Q | 9, &c. they shall all be the true Hour-lines for such a *Vertical* or *Horizontal Plain.* Namely, for twelve of them, that is, from 6 in the Morning till 6 at Night.

But for the Hours before and after 6, that is, for 4 and 5 in the Morning, and for 7 and 8 at Night, they are to be drawn by extending the Hour-line of 7 and 8 in the Morning through the

the Center Q, and drawing them on the other side of the *Plain,* so shall they be the Hours of 7 and 8 at Night : —— Also the Hour-lines of 4 and 5 in the Evening, being drawn through the Centre Q, will become the Hour-lines of 4 and 5 in the Morning.

For the Stile of this *Dial,* take 51 deg. 32 min. the Latitude of your Place, out of your Line of Chords, and set them from N to *e,* upon the Circle of the *Plain,* so shall a Line drawn from Q through *e,* be the *Axis* or *Stile-of the Dial,* which may be a thin Plate of Brass, cut exactly to the Quantity of the Angle *e* Q N. 51 deg. 32 min. and set perpendicularly upon the Line of 12, or the Meridian S Q N, with the Angular point at Q, and thus is your *Dial* finished.

If into this, or any of the following *Dials,* you have a Desire to insert the half Hours and Quarters, divide the Spaces between every one of the points ☉ ☉ into two equal parts for the Half, and into 4 equal Parts for the Quarters of Hours, and proceed with putting on of them in all Respects as you did with the whole Hours.
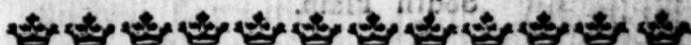
II. *Of Upright or Erect Plains.*

CHAP. IV.

THOSE *Plains* are said to be *Erect* or *Upright,* which stand perpendicular to the *Horizon* of the *Place,* whose Vertex or upper part tendeth to the *Zenith,* and their lower part to the *Nadir,* and such are the Walls of Steeples,

Churches,

Churches, Houses, or the like, against which (for the most part) *Dials* are made.

Of these *Upright* or *Erect Plains* there are two sorts, *viz. Direct* and *Declining.*

Those *Erect* or Upright *Plains* are said to be direct, which do directly behold either the true East, West, North, or South Points of the *Horizon,* or whose *Poles* do lie directly in either of them, and these *Plains* are called *Erect Direct Plains.*

Those *Erect* or Upright *Plains* are said to decline, which do not lie in, or directly behold any of these Points, but are situate under some other *Azimuth,* as *South-East, North-West, North-East,* &c. and these *Plains* are called *Erect* or *Upright Declining Plains.* Of both which sorts I shall give you Examples. And.

❀❀❀❀❀❀❀❀❀❀❀❀❀❀❀

I. *Of Upright, or Erect Direct Plains.*

CHAP. V.

How to draw the Hour-lines upon a Direct *South Plain.*

Example, Of a Direct South Plain, *in the Latitude of* London, 51 deg. 32 m.

FIRST, Draw a Circle Z E W N, representing an upright direct South Plain; cross it at right Angles with the Diameters Z Q N for the Meridian, or Hour-line of 12, and W Q E for the prime *Vertical Circle,* or *Hour-line* of Six.

Secondly, Out of your Line of Chords take 38 deg. 28 min. (which is the Complement of
the

the *Latitude* of the *Place*) and fet that Diftance upon the *Dial-Plain* from Z to *a*, and from E to *b*, and from N to *e*.

Thirdly, Lay a Ruler from W. to *a*, it will cut the Meridian Z N, in the point P, the *Pole* of the World; and a Ruler alfo laid from W to *b*, will cut the Meridian in Æ, fo is Æ the point through which the Æquinoctial muft pafs; and for the drawing of it you have three points given, *viz.* E, Æ, and W, and the Center will always be in the Meridian Line Z N, (extended if need be.) The Center you may find by the Geometrical Way taught at the Beginning of the Book. Or thus, Draw the Line E Æ, and divide it into two equal parts in A, upon A erect the *Perpen-*   *An Erect Direct* *dicular* A C, extending it, till   *South Plain. Pl.* that and the Meridian Line   *2. Fig. 3.* concur in G, fo is G the Center of the *Æquinoctial Circle* E Æ W.

Fourthly, Divide the Semicircle E N W into 12 equal parts, at the points ⊙ ⊙ ⊙, *&c.*

Fifthly, Lay a Ruler to Q, and each of thefe points ⊙ ⊙ ⊙, and the Ruler will crofs the *Equinoctial Circle* in the points ***, *&c.* dividing that into 12 unequal parts.

Sixthly, Lay a Ruler to P, (the *Pole* of the World) and every of the Marks ***, *&c.* and the Ruler will crofs the Circle of the *Plain* in the points [[[, *&c.*

Laftly, If through the Centre Q, and the refpective Points [[[*&c.* you draw right Lines, they fhall be the true Hour-lines of an *Erect Direct South Plain.*

For the Stile, take 38 deg. 28 min. the Complement of the Latitude of your place, out of the Line of Chords, and fet them from N to *e*,

E 3   drawing

drawing the Line Q *e* for the Axis of the Stile, which must hang directly over the Meridian, or Hour-line of 12, and must point downwards towards the South *Pole*, because the Plain beholds the South part of the Meridian.

In making this Dial you have made two Dials, for the *Erect Direct North Dial* is but the back-side of the *South*, it lying in the same Prime Vertical Circle, only as this beholdeth the South part of the Meridian, and hath the South *Pole* elevated above it, the other beholdeth the North part of the Meridian, and hath the North *Pole* elevated above it, and as the Meridian Line Z Q N in the South *Dial* representeth the 12 a Clock Hour-line at Noon, the back-side thereof (namely the North-side) representeth the Hour-line of 12 at Midnight, and therefore is not expreſſed, neither the Hour-lines of 9, 10, 11 at Night, or of 1, 2, 3 in the Morning, the Sun to us never being above the Horizon at thoſe Hours : Wherefore the North Dial is only capable of receiving theſe Hours, namely, 4, 5, 6, 7 and 8 in the Morning, and of 4, 5, 6, 7 and 8 at Night, and (in this Latitude) not of all them neither ; for it will never shine upon this Plain

An Erect Direct North Plain. Plate 2. Fig. 4. at 8 in the Morning, or at 4 in the Afternoon, but it is beſt to put them on (as in the Figure) that thereby you may know how much it is paſt 7 in the Morning, and how much it wants of 5 in the Afternoon.

CHAP. VI.

Fig. 1

Fig. 2

Plate 2

Fig. 3

Fig. 4

Fig. 5
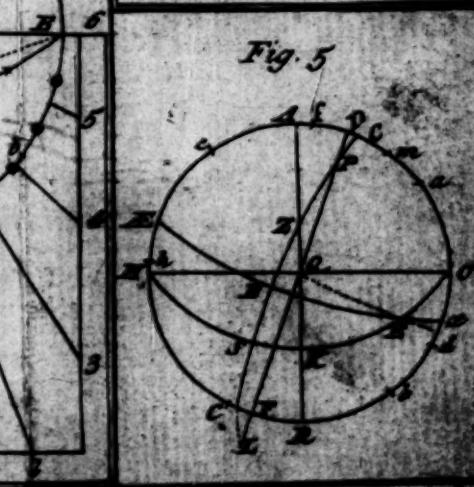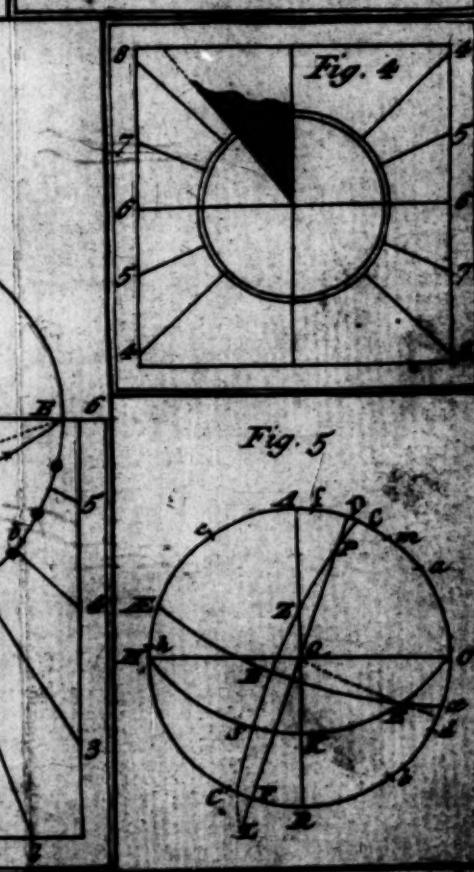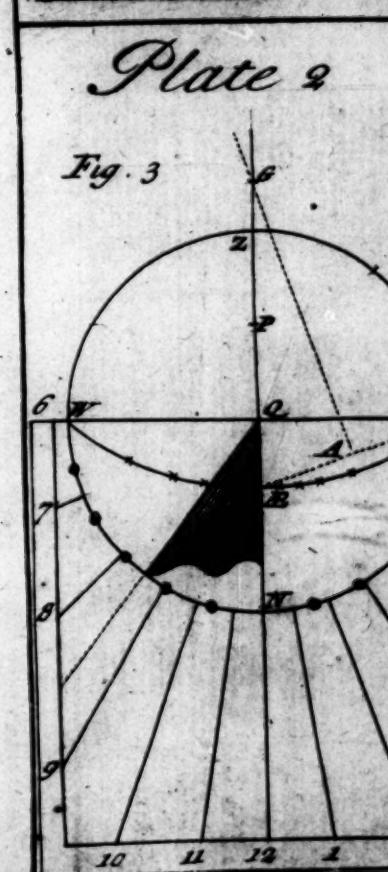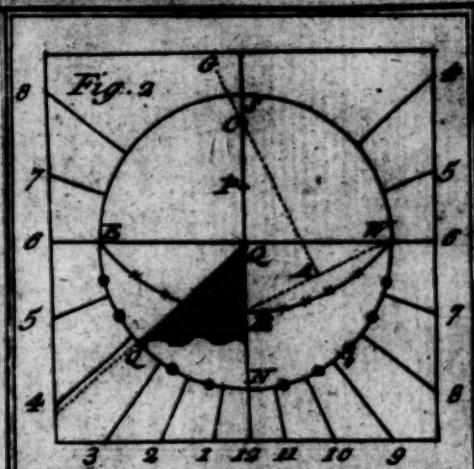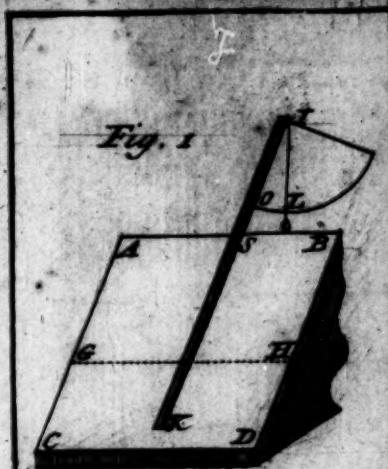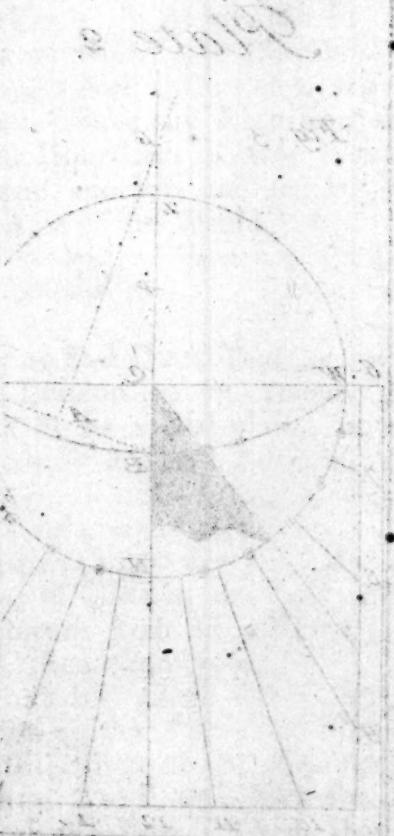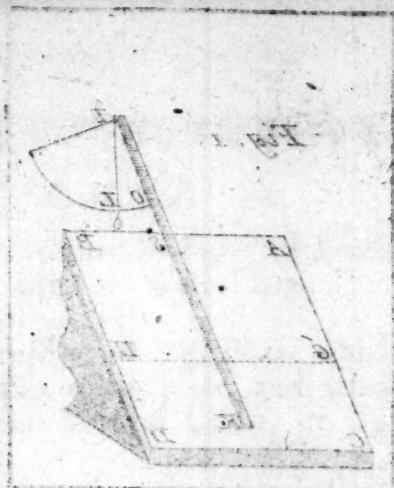
CHAP. VI.

How to draw the Hour-lines upon an Erect, Direct, Eaſt, *or* Weſt Plain.

I Call that an *Eaſt* or *Weſt Plain*, which lies in the Meridian of the place, and whoſe Poles lie in the prime Vertical Circle, or *Azimuth* of Eaſt or Weſt.

Now for as much as the *Plain* lieth in the very Meridian Circle, in which alſo the two *Poles* of the World are ſeated, the *Plain* muſt neceſſa-rily paſs through both theſe Poles, and ſo nei-ther of them can have any Elevation above it ; wherefore the Hour-lines in theſe *Dials* muſt be parallel to one another, and conſequently pa-rallel to the Axis of the World. And the Dial muſt have no Center : However the Dial may be drawn as followeth.

Example, *Of an* Eaſt Direct *Dial, in the Latitude of* London 51 *deg.* 32 *min.*

Let A B C D be a Dial-plain, upon which you would draw a direct *Eaſt Dial*, upon the point D, if it be an Eaſt Dial ; or upon the point C, if it be a Weſt Dial ; with the Radius (or 60 deg.)   *An Erect Di-* of your Line of Chords, de- *rect Eaſt Dial.* ſcribe an obſcure Arch of a   *Plate* 3. *Fig.* 1. Circle E F, then from your Chord take 38 deg. 28 m. the Complement of the Latitude of the Place, (which is alſo the Height or Elevation of the Æquinoctial) and ſet them from E to F, and draw the Line D F quite through the Plain. Then, that you may pro-

proportion your ſtile to your Plain, ſo that you may bring on all the Hours from Sun-riſing to 11 a Clock, aſſume two points in the Line F D, one towards the End D (at the point G) for the Hour-line of 11, and another at H, for the Hour-line of 6, and through the points G and H, draw the Lines 11 G 11, and 6 H 6, perpendicular to the Equinoctial Line D F. This done, upon the point G, with 60 deg. of the Line of Chords, deſcribe an obſcure Arch of a Circle I K, and ſet thereon 15 deg. of your Line of Chords from I to K, and draw the Line G K, to cut the Line 6 H 6 in the point L, ſo ſhall L H be the Height of the perpendicular Stile proportioned to this Plain.

Now for the drawing of the Hour-lines, ſet one Foot of the Compaſſes, (opened to 60 deg. of the Chord) in L, and with the other deſcribe the Arch of a Circle M N, betwixt the Hour-line of 6, and the Line G L, which divide into 5 equal parts in the points ⊙ ⊙ ⊙ ⊙ ⊙, and a Ruler laid from the point L to each of theſe points, ⊙ ⊙ ⊙, &c. will cut the Æquinoctial Line H D, in the points * * * * *, through which points draw Lines parallel to 6 H 6, as the Lines 7 * 7, 8 * 8, &c. and they ſhall be the true Hour-lines of an *Eaſt Plain*, from 6 in the Morning till 11 before Noon, but for the Hours of 4 and 5 in the Morning, you may put them on by ſetting the ſame Diſtances upon the Æquinoctial Line before 6, as there is from 6 to 7 and 8, after 6; and through thoſe points draw the Hour-lines of 4 and 5, parallel to the Hour of 6, as you ſee done in the Figure.

Thus is your *Dial* finiſhed, and in the making of it you have made two *Dials*, namely, a *Weſt Dial* as well as an *Eaſt*, for it is the ſame in all Reſpects,

Refpects. Only whereas the Arch A F, through
which the Æquinoctial paffeth in the Eaft *Dial,*
was drawn on the right-hand of the Plain, in
the Weft it muft be drawn on
the left-hand, and the Hour-   *An Erect, Direct*
lines of 4, 5, 6, 7, 8, 9 10,   *Weft Dial.* **Plate**
and 11, in the Forenoon on   3. *Fig.* 2.
the Eaft Dial, muft be 8, 7, 6,
5, 4, 3, 2, and 1 in the Afternoon upon the
Weft Dial.

The Stile of the Eaft or Weft *Dials,* may be
either a ftrait Pin of the juft Length of the
Line H O, which is equal to H L in the Eaft
Dial, fixed in the point H, upon the Hour-line
of 6, and exactly perpendicular to the Plain,
fhewing the Hours of the Shadow of the Apex,
or very Top thereof.

Or, it may be a Plate of Brafs of the fame
Breadth with the Diftance between the Hour-
lines of 6 and 3, which Plate muft be fet per-
pendicular upon the Hour-line of 6, and fo it
will fhew the Hour by the Shadow of the up-
per Edge thereof, as in this Weft Dial.

Thefe five Dials here defcribed, *viz.* the *Ver-
tical,* the *South, North, Eaft,* and *Weft* Erect, Di-
rect, may be made upon a Stone cut fquare in
Form of a *Die,* which Body is called a Cube.
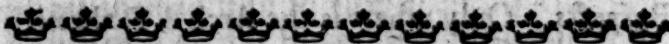
II. *of*

II. *Of Upright Declining Plains.*

CHAP VII.

How to draw the Hour-lines upon a South or North Erect Plain, Declining either East or West.

THE upright or erect Plains, that we have hitherto treated of, are such as did directly behold the four Cardinal or principal Points of the Horizon ; namely, the *East*, *West*, *North* and *South* Points. All other upright Plains are said to decline, and their Declination is counted from the North or South, towards East or West, and these Plains are called South or North Erect Plains declining East or West.

Before the Hour-lines can be drawn upon any of these Plains, two Things must be given, and three other things must be found. ——

The Things given must be,

1. The Latitude of the Place.
2. The Declination of the Plain.

The Things required are,

1. The Height of the *Pole* (or *Stile*) above the Plain.
2. The Distance of the *Substile* from the Meridian, or 12 a Clock Hour-line.
3. The *Plain*'s Difference of Longitude.

For the finding of these, we must project upon the *Plain* such Circles of the Sphere (in their
true

true Positions) as are requisite for the finding of them, and those Circles are, the *Horizon*, the *Meridian*, and the *Æquinoctial* : which I shall shew how to perform by giving an

Example of a South Erect Plain, *declining* Westward 24 *deg.* 20 *min. in the Latitude of* London 51 deg. 32 min.

Given $\begin{cases} \text{Latitude of the Place} & \begin{array}{cc} d. & m. \\ 51 & 32 \end{array} \\ \text{Declination } South West & 24 \quad 20 \end{cases}$

Required $\begin{cases} \text{Distance of the Subftile from} \\ \quad \text{the Meridian,} \quad\quad\quad 18 \quad 8 \\ \text{Height of the Pole (or Stile)} \\ \quad \text{above the Plain,} \quad\quad 34 \quad 33 \\ \text{Plain's Difference of Longit. } 30 \quad 00 \end{cases}$

To find which,

First, Describe the Circle Z H N O, representing the declining Plain, crofs it at right Angles, with the two Diameters Z Q N, and H Q O, the Point Z reprefenting the Zenith, and N the Nadir, and the Line Z Q N, the Vertical or Perpendicular Line of the Plain (and the Hour-line of 12) and the Line H Q O is the Horizontal Line thereof.

Secondly, Becaufe the Plain declines 24 deg 20 min. from the South Weftward, fet 24 deg. 20 min. from N to *a*, and from O to *c*. Then lay a Ruler from Z to *a*, and it will cut the Horizontal Line H Q O in S, fo is S the South Point of the Horizon, through which the Meridian mult be drawn, and for the drawing of it, you have three Points, *viz.* Z S and N, and the

Center

An Upright Plain Declining from the South Westward 24 deg. 20 m. Plate 3. Fig. 3.   Center will always be in the Horizontal Line H Q O, extended if need be. Which Center may be found *Geometrically*, as is formerly taught. Then lay a Ruler from Z to *c*, and it will cut the Horizon in W, the West Point thereof.

Thirdly, Having drawn the Meridian and the Horizon, take 51 deg. 32 min. out of your Line of Chords, and set them upon your Plain, from H to *b*, and from N to *d*.

Fourthly, Lay a Ruler upon W, the West point of the *Horizon*, (which is also the Pole of the Meridian) to *b*, and it will cut the Meridian in the point P, so shall P be the Pole of the World, through which point P, and Q (the Pole of the *Plain*) draw the strait Line B P Q D, representing the Axis of the World, and the Substilar Line of the Dial.

Fifthly, Lay a Ruler from W to *d*, and it will cross the Meridian in the Point Æ, so is Æ one Point in the Meridian, through which the Æquinoctial must pass : And the Point W in the Horizon is another. So have you two Points within the Circle, by which to draw the Æquinoctial, which you may do *Geometrically*, as is before taught. Or you may find it thus, the Centre of the Æquinoctial will always be in the Axis of the World, and therefore in the Line B P Q D. Now to find the Point, draw the Line Æ W, which divide into two equal parts in the Point *n*, upon *n* erect a Perpendicular, till it cut the Axis of the World, extended in *m*. So is *m* the Centre of the Æquinoctial, upon which Point you may describe it. And thus have you drawn upon your Plain all the three Circles the

required, *viz.* the *Horizon,* *Meridian,* and the *Æquinoctial* ; by which may be found the three Requisites belonging to this Plain. For,

1. *To find the Height of the Pole above the Plain,* *represented in the Scheme by the Line* P B. Lay a Ruler to G, where the *Æquinoctial* cuts the Plain, and to P the Pole of the World, the Ruler will cut the Plain on the opposite side in the Point *v.* So the Distance from B to *v,* measured upon the Line of Chords, will be found to contain 34 deg. 33 min. The Height of the Pole above the Plain.

2. *To find the Distance of the Substile from the Me-* *ridian, represented in the Scheme by the Arches* Z B, or N D. Take in your Compasses the Distance Z B, or N D, and you shall find either of thom equal to 18 deg. 8 min. and such is the Distance of the Substile from the Meridian.

3. *To find the Plain's Difference of Longitude, re-* *presented in the Scheme by the Angle* Æ P K. Lay a Ruler from P to Æ, it will cut the Plain in *x,* so the Distance between D and *x,* measured upon the Line of Chords, will be 30 deg. And such is the Plain's Difference of Longitude.

Lastly, These Requisites being obtained, we come to the drawing of the Hours ; to effect which, lay a Ruler to P, the Pole of the World, and Æ, the Intersection of the *Æquinoctial* with the *Meridian,* and it will cut the Plain in the point *x.*——— At this point *x* begin to divide the Semicircle L *x* G, into 12 equal parts, at the points ☉ ☉ ☉, *&c.* Then laying a Ruler to O, and every of these points ☉ ☉ ☉, *&c.* it will cut the Equinoctial Circle, dividing that into

12 unequal parts in the Points * * * *, &c.——
Again, A Ruler laid to P, and every of these
unequal parts * * * *, &c. will divide the Plain
into 12 unequal parts in the points ‖ ‖ ‖, &c.——
Lay a Ruler to Q, and every of these Points ‖ ‖,
&c. drawing Lines by the side thereof, and they
shall be the true Hour-lines proper to such a De-
clining *Plain*.

Thus have you finished the Hour-lines, the
Substilar-line, (or the Line upon which the
Stile must stand) is the Line QD, falling (in
this *Dial*) just upon the Hour-line of 2 in the
Afternoon, because the *Plain* declined Westward.
The Angle of the *Stile* is DQR, containing 34
deg. 33 min. and must be either of *Plate* or
Wire brought to such an Angle, and must stand
perpendicular to the *Plain*, and directly over the
Substilar QD.

Now have you finished your *Dial*, and in so
doing you have in this one made four *Dials*,
viz.

A $\left\{\begin{array}{l}\text{South declining West} \\ \text{South declining East} \\ \text{North declining West} \\ \text{North declining East.}\end{array}\right\}$ $\left.\begin{array}{l} \\ d. \quad m. \\ 24 \quad 20 \\ \end{array}\right.$

Only placing of the Numbers of the Hours and
the Stile respectively upon each *Plain*. For in
the South-west *Plain*, which we have now de-
scribed, the *Stile* stands upon the Hour of 2 in
the Afternoon; in the South-East declining as
much, it will stand upon the Hour-line of 10
before Noon. And so all the Morning Hours
of the West Decliner, will be the Afternoon
Hours of the East Decliner; and the Afternoon
Hours of the West Decliner, will be the Morn-
ing

ing Hours of the East Decliner : And so the South Decliner will produce the North-west Decliner ; and the South-west Decliner, the North-East Decliner, by only extending the Hour-lines, Stile, and Substile quite through the Centre. *The four upright Declining Dials. Plate 3. Fig. 4.*

And that there may yet remain no Doubt, I have drawn all the four *Dials* in one, by which you may plainly see that there is no Difference between them, but what hath been already intimated. Only before I leave them, I will, (because these Dials are most in use) give you one other Example of an upright declining *Plain*, which by reason of its great Declination from the *Prime Vertical*, or its *Poles* great Deviation from the Meridian, causeth the *Pole* to have but small Elevation, wherefore the *Dial* (as all such like) must be drawn without a Center, by the Directions following.

CHAP. VIII.

How to draw the Hour-lines upon Upright far Declining Plains, which by reason of the small Elevation, which the Pole hath over such Plains, the Hours (if they be drawn from a Center) cannot be of any competent Distance one from another.

THOSE *Plains* which lie near to the Meridian *Circle*, and whose *Poles* (consequently) near the *Prime Vertical Circle*, or Azimuth of East or West ; the *Pole* hath but small Elevation above such *Plains*, so that the Hour-lines (especially those of them which fall near to the *Sub-stile*)

ftile) from the Center, cannot be drawn at any competent Diſtance, without a large Extention of them. To remedy which Inconvenience, you may draw the Hour-lines for ſuch a *Plain* at a convenient Diſtance, and in a little Room, without any Regard had to the Center. But before you proceed to draw the *Dial*, you muſt firſt find the three Requiſites mentioned in the laſt Chapter, *viz.*

  1. *The Height of the Pole above the Plain.*

  2. *The Diſtance of the Subſtile from the Meridian.*

  3. *The Plain's Difference of Longitude.*

Example of an Upright South Plain, declining Eaſtward 80 deg. in the Latitude of London 51 *deg.* 32 *min.*

To find theſe Requiſites.

Firſt, Draw the Circle Z H N O, **Plate 3.** croſſing it with the Diameters Z N, **Fig. 5.** the Perpendicular, and H O, the Horizontal Line of the *Plain*.

Secondly, Becauſe the *Plain* declineth 80 deg. Eaſtward, ſet 80 deg. from N to *a*, and from H to *b*.

Thirdly, Lay a Ruler to Z and *a*, it will cut the Horizon in S, the South point thereof, and a Ruler laid to Z and *b*, will cut the Horizon in E, the Eaſt point thereof.

Fourthly, Having the three points Z S and N, through them draw the Meridian Z S N, whoſe Center (by any of the ways before taught) will be found to be at *m*.

            Fifthly,

Fifthly, Out of your Line of Chords take 51 deg. 32 min. the Latitude, and set them from O to *c,* and from N to *d.* Then laying a Ruler from E to *c,* it will cut the Meridian in P, the *Pole* of the World ; through which point P and Q, the Center of the Plain, draw the right Line P Q B, for the Axis of the World. Also the Ruler laid from E to *d,* will cut the Meridian in Æ, so is Æ one point in the Meridian, through which the Equinoctial must pass, and R is another point in the Meridian (extended) without the Circle, and a third point is E, the East point of the Horizon. Now forasmuch as these three points R E Æ, through which the Æquinoctial is to be drawn, are almost in a strait Line, so that the Center of it will be at a very great Distance, we will forbear describing of that Circle, and content ourselves that we have found the points R E Æ, through which it should pass ; because we shall draw the Hour-lines in this and the like Cases by other Means, and therefore I shall proceed to find the other Requisites. And,

1. To *find the Height of the Pole above the Plain,* represented by P C.———— Take 90 deg. of your Line of Chords, and set them from *c* to *e,* a Ruler laid to *e* and P, will cut the *Plain* in *o,* so is *o* C the Height of the *Pole* (or *Stile*) above the *Plain, viz.* 6 deg. 12 min.

2. To *find the Distance of the Subftile from the Meridian,* represented by B N or Z *c.* ————Take the Distance B N or Z *c* (which is equal thereto) in your Compasses, and measure it upon your Line of Chords, so you shall find it to contain 38 deg. 4 min.

An Erect South Plain Declining Eastward 80 *deg. Plate* 4. *Fig.* 1.

F 3 which

which is the Diſtance of the *Subſtile* from the Meridian.

3. *To find the Plain's Difference of Longitude, repreſented by the Angle* Q P Æ. —— Lay a Ruler upon P and Æ, it will cut the *Plain* in *g*, the Diſtance *g* B, meaſured upon the Line of Chords, will contain 82 deg. 8 min. the *Plain's* Difference of Longitude.

Theſe three Requiſites being thus found, I will now proceed to draw the *Dial*, without any Regard had to the Center.

How to draw the Hour-lines upon the Plain.

Firſt, Draw a right Line A B, for the perpendicular Line of your *Plain*, and upon A as a Center, with 60 deg. or the Radius of your Chord, deſcribe an obſcure Arch of a Circle C D E, and thereon from C to D, ſet 38 deg. 4 m. the *Subſtile's* Diſtance from the Meridian before found, and draw the Line A D for the *Subſtile*, quite through the *Plain*.

Secondly, Take 6 deg. 12 min the Height of the *Pole* above the *plain* from your Chord, and ſet them upon the ſame Arch from D to E, and draw the Line A E for the *Stile*.

Thirdly, Foraſmuch as the *Stile* A E in this Caſe is but of ſmall Elevation, *viz.* but 6 deg. 12 min. Draw the Line G H parallel to A E, at ſuch convenient Diſtance as you ſhall think fit, for your new (or augmented) *Stile* to ſtand from your *Subſtile* A D.

Fourthly, Aſſume any two points in the *Subſtile* A D, as R and S, and through theſe two points draw two infinite right Lines, both of them at right

right *Angles* to the *Subſtilar* Line A B, as the Lines Z Z, and X X.

Fifthly, From the point R, take with your Compaſſes the leaſt Diſtance to the new augmented *Stile* G H, and ſet that Diſtance upon the *Subſtilar* Line, from R to K : Alſo from the point S, take the leaſt Diſtance to the new Stile G H, and ſet that Diſtance alſo upon the *Subſtilar* Line from S to L.

Sixthly, Upon the two points K and L (as upon two Centers) with 60 deg. or the Radius of the Line of Chords, deſcribe the Portions of *Circles,* and in either of them ſet off 82 deg. 8 min. the *Plain's* Difference of Longitude, as from *S* to M, and from R to M, both on the ſame ſide of the *Subſtilar Line,* on which the Perpendicular Line of the Plain A B was drawn.

Seventhly, Divide either of the Semicircles laſt drawn into 12 equal parts, at the Points ☉ ☉ ☉, &c. beginning this Diviſion in either of them, at the point M.

Eighthly, Lay a Ruler to the Point L, and every of the Diviſions ☉ ☉ ☉, &c. and the Ruler will cut the Contingent or *Æquinoſtial* Line X X, in the points * * *, &c. Alſo a Ruler laid to K, and each of the Points ☉ ☉ ☉, &c. will cut the other Contingent Z Z. in the points * * *, &c.

Laſtly, Lines drawn from the point * in one Contingent Line, to the point * in the other contingent Line, each to his Correſpondent (which the *Subſtilar Line* will direct you how to do) thoſe Lines ſhall be the true Hour-lines belonging to ſuch a *Declining Plain,* and be drawn as in the Figure you ſee done, at a competent Diſtance one from another, without any Relation at all had to the Center of the *Dial.*

Thus

Thus have you finished your *Dial*, and in the making of this, you have made a South declining West 80 deg. also; for if you turn the Paper, and look through it, it will on the backside be a South declining West 80 deg. only the Forenoon Hours in this, must be the Afternoon Hours in that : Nay, rather, you have in this one Dial made four, *viz.* a North declining either East or West, if you well observe what was said and done in the last Chapter.

And thus have I done with all *Upright* or *Erect Plains*, either *Direct* or *Declining.* I shall now proceed to shew you how to inscribe Hour-lines upon such *Plains* as are not upright, but *Recline* from the *Zenith*, and of them there are such as are *Direct*, and such as do decline.

III. *Of* Reclining Plains.

C H A P. IX.

AS in upright *Plains* there were two Varieties, *viz. Erect Direct*, and *Erect Declining* ; so are there of *Reclining Plains* also. For such *Reclining Plains* as do directly behold either the true *East*, *West*, *North*, or *South* Points of the Heavens, that is, whose Poles lie either in the *Meridian*, or *Prime Vertical Circle* of the Place, are called *Direct Reclining Plains.*

Again, Those *Reclining Plains* which do not directly lie in, or their Poles be not in the prime Vertical or Meridian Circles of the place, but
deviate

deviate therefrom, are called *Declining Reclining Plains*. Of both which sorts I shall give you an Account, and the manner of inscribing Hour-lines upon them, for in these Plains there is far more Variety, than there was in Upright or E-rect Plains.

Of Direct Reclining Plains, &c.

I. *Of East and West Recliners.*

CHAP. X.

How to draw the Hour-lines upon a Direct East or West Reclining or Inclining Plain.

AS in upright declining Dials, two Things must be given, and three Things must be found, before the Hour-lines can be drawn ; so in these direct reclining Plains, two Things must also be given, and three must be found, before the Dial can be made.

The Things that must be given, are,

1. The Latitude of the Place.
2. The Reclination of the Plain.
The Reclination of a Plain, (as hath been before declared) is the Arch of an Azimuth or Vertical Circle, intercepted between the Zenith of the place, and the Reclining Plain.

Example,

Example, Of an *East* or *West* *Plain,* *Reclining*
35 *deg.* in the Latitude of *London,* 51. *deg.*
32 *min.*

		d.	m.
Given {	Latitude of the Place	51	32
	Reclination of the Plain	35	00

Required {

The Height of the Pole above the
  Plain.
The Distance of the Substile from
  the Meridian.
The Plain's Difference of Longitude.

First, Draw the Circle N E S R, reprefenting
the Reclining Plain, and crofs it with the two
Diameters N Q S, the Horizontal Line of the
Plain, and the Hour-line of 12 a Clock, and
E Q R for the prime Vertical Circle.

Secondly, Becaufe the Plain reclines 35 deg.
take 35 deg. out of your Line of Chords, and
fet them from E to *a,* and from N to *b.*

Thirdly, Lay a Ruler from S to *a,* and it will
cut the prime Vertical Circle in Z, fo is Z the
Zenith of the place—— Alfo a Ruler laid from
S to *b,* will cut the fame Vertical Circle in W,
by which point the Horizon of the place muft
be drawn.

Fourthly, The points Z and W being found,
              you have three points through
East and West which you muft defcribe the
Inclining. *Plate* *Meridian,* viz. N Z and S; and
4. *Fig.* 2.   as many alfo through which you
              muft draw the *Horizon,* name-
ly, N W and S. The Centers of both which
Circles will fall in the Line E Q R, (extended
                                        if

if need be) and the manner how to find them hath been often enough already taught.

Fifthly, Becaufe the Latitude of the place is 51 deg. 32 min. Take 51 deg. 32 min. from your Line of Chords, and fet them upon your Plain from S to *c.* Then lay a Ruler upon W, the Weft point of the *Horizon,* and the point *c,* the Ruler will crofs the *Meridian* Circle in P the Pole of the World ; through which point P and Q, the Center, (or Pole of the *Plain*) draw the right Line P Q, which fhall be the Subfti-lar Line of your Dial.

Sixthly, Take 90 deg. of your Line of Chords, and fet them upon the Circle of your *Plain* from *c* to *d,* then lay a Ruler from W to *d,* and it will cut the *Meridian Circle* in Æ, fo is Æ one point in the *Meridian,* through which the Æqui-noctial Circle muft be drawn, and W the weft Point of the Horizon is another ; fo have you two points within the Circle, through which you muft defcribe the *Æquinoctial Circle,* whofe Center will be in the Line P Q, the Axis of the World, (extended if need be) the manner how to find it hath already been taught feveral ways.

Having thus projected the Meridian, Hori-zon, and Æquinoctial, you may find the three Requifites, as followeth.

1. To *find the Height of the Pole above the Plain* P *k,* Lay a Ruler to *g* and P, it will cut the *Plain* on the oppofite fide in *h* ; fo *k h* mea-fured upon the Chords, will be 26 deg. 41 min. The *Height of the Pole above the Plain.*

2. To *find the Diftance of the Subftile from the Meridian* S *k,* Take *s k* in your Compaffes, and meafure it upon the Chord, it will be

<div align="right">found</div>

found 45 deg. 52 min. *The Distance of the Substile from the Meridian.*

3. *To find the* Plain's *Difference of Longitude,* Æ. P Q. A Ruler laid from P to Æ, will cut the Plain in *e*, the Distance from O the Substile, to *e* will contain 66 deg. 27 min. of the Chord, which is *The Plain's Difference of Longitude.*

These Requisites being obtained, you may proceed to find the Hour Distances upon the Plain in this manner.

Seventhly, Lay a Ruler to P the Pole, and Æ the Intersection of the Meridian with the Æquinoctial, and it will cut the Plain in *e*. At *e* begin to divide the Semicircle into 12 equal parts, at the points ⊙ ⊙ ⊙, &c.

Eighthly, Lay a Ruler to Q, and the several points ⊙ ⊙ ⊙, &c. and it will cut the Æquinoctial Circle in the points ***, &c. dividing that into 12 unequal parts.

Ninthly, Lay a Ruler to P, and the several points ***, &c. and it will cut the Plain in the points ‖ ‖, &c.

Lastly, If from the Centre Q, you draw right Lines through the points ‖ ‖, &c. they shall be the true Hour-lines belonging to the *Reclining* Plain.

And thus have you finished your *Dial,* and also in it 4 *Dials*: For the *Dial* as it here stands in the Scheme, is properly an East and West *Incliner,* but being turned upside down, as you see the Hours numbred, and the Word *Zenith* standing upwards, it is an East *Recliner* ; and if the Hour-lines be turned, (or supposed to stand) on the right Hand of the prime Vertical Line E Q R, as in this Scheme they do on the left Hand, and

and the Hours of 4, 5, 6, &c. in the Morning changed to 8, 7, 6, in the Evening, the the Plain is then a Weſt *Recliner.* And if the Hour-lines be drawn through the Center of either of them, the Plains then become Eaſt and Weſt *Incliners*; the Hours and Subſtile in all retaining the ſame place, only the Denominations of the Hours changed, &c. you muſt remember, that in all Eaſt and Weſt *Recliners*, the North Pole is elevated, and in all *Incliners* (oppoſite to them) the South Pole.

II. *Of South Recliners.*

C H A P. XI.

How to draw the Hour-lines upon Direct South Reclining or Inclining Plains.

IN the Eaſt and Weſt Reclining and Inclining Plains, before deſcribed, the Meridian, or 12 a Clock Hour-line did lie in the Horizontal Line of the Plain, and the Poles thereof in the prime Vertical Circle. So (on the contrary) in theſe South and North Reclining and Inclining Plains, their *Horizontal Line* lieth in the prime Vertical Circle, or Hour of 6, and their Poles in the Meridian, and from hence they receive their Denomination.

Of theſe Direct Reclining Plains there are Six Varieties, *viz.* Three of South Recliners, and as many of North Recliners. For,

1. The South Plain may recline, ſo as it may juſt fall in the Axis of the World, and ſo paſs

<center>G</center> through

thtough the Poles of the World, and then it is called an *Æquinoctial* Plain, becauſe the Poles thereof lie in the *Æquinoctial Circle*, and neither of the Poles have any Elevation above it ; wherefore the Hour-lines muſt be all parallel one to the other, and all of them to the Axis of the World, and the *Dial* muſt be drawn as the Erect Direct Eaſt or Weſt *Dials* were. Only, whereas the Stile ſtood upon the Hour-line of 6 in the Eaſt and Weſt, in theſe Plains it muſt ſtand upon the Hour-line of 12, and be of equal Height with the Diſtance between the Hours of 12 and 9, or 12 and 3, which are equidiſtant from the Meridian.

2, Or *Secondly*, The South Plain may ſo Recline, that it may fall between the Zenith and the North Pole, and then is the South Pole elevated above ſuch a Plain. Or,

3. The South Plain may ſo recline, that it may fall between the Horizon and the North Pole, and then is the North Pole elevated.

Examples of theſe three Varieties of South Reclining plains do here follow.

The First Variety.

C H A P. XII.

How to draw the Hour-lines upon an Æquinoctial Plain, or a Plain reclining just to the Pole.

FIRST, Draw the right Line A B, for the *Horizontal Line* of the Plain, and cross it about the middle thereof at right Angles, with the Line 12 Q 12 for the Meridian and Hour-line of 12.

Secondly, Upon the Line 12 Q 12, either above or below Q, assume any point, as S, and setting one Foot of your Compasses therein, (it being opened to the Radius of your Line of Chords) describe the Semicircle C D E, which divide into 12 equal parts, beginning at D.

Thirdly, Lay a Ruler to S, and the several points ☉ ☉ ☉, &c. and it will cross the Æquinoctial Line A B, in the points * * *, &c.

Lastly, Through these points * * * &c. draw right Lines all parallel to the Line 12 Q 12, and so is your Dial finished.

A Direct Æquinoctial Dial. Plate 3. Fig. 6.

The Stile may be either a strait Pin, of the Length of the Line Q S, set perpendicular to the *Plain* upon the point Q ; the Shadow of the Top thereof only giving the Hour. Or it may be a Plate of the Breadth of the Distance that is between the

G 2 Hour.

Hour-lines of 12 and 3, or 12 and 9, and then will the Shadow of the upper Edge thereof give the Hour of the Day.

❀❀❀:❀❀❀❀❀❀❀ ❀❀❀❀❀❀❀:❀❀❀

The Second Variety.

CHAP. XIII.

How to draw the Hour-lines upon a Direct South Reclining Plain, which falls between the Zenith and the Pole.

Let the Example be of a *South Plain Reclining* 25 d. in the Latitude of *London*, 51 deg. 32 min.

FIRST, Draw the Circle W D E R, cross it with the two Diameters D R, for the Meridian and Hour-line of 12, and W E, for the Horizontal Line of the *Plain*, and Hour-line of Six.

Secondly, Take 25 deg. the *Plain's* Reclination, out of your Line of Chords, and set that Distance from D to *a*, and from E to *b*.

Thirdly, A Ruler laid from W to *a*, will give Z the Zenith of the Place ; and a Ruler laid from W to *b*, will give S the South point of the Horizon ; both which Circles W Z E, the *Prime Vertical* and W R E the *Horizon*, may be drawn, as hath often enough already been shewn, their Centers being always in the Meridian Line D Q R, extended, if need require.

Plate 4.
Fig. 3.

Fourthly,

Fig. 1

Fig. 2

Fig. 3
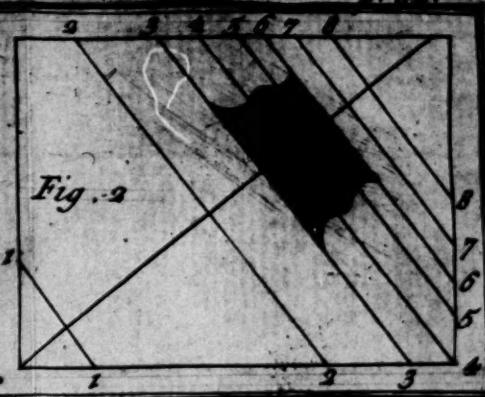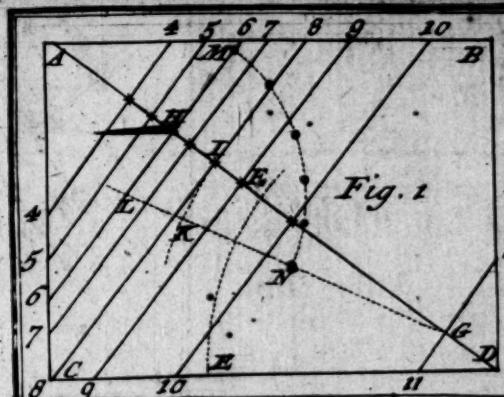
Plate 3.

North Declining East and South Declining West 24° 20'

North Declining West and South Declining East 24° 20'

Fig. 4

Fig. 5
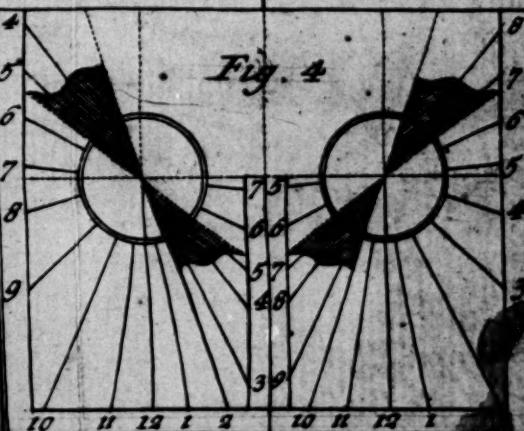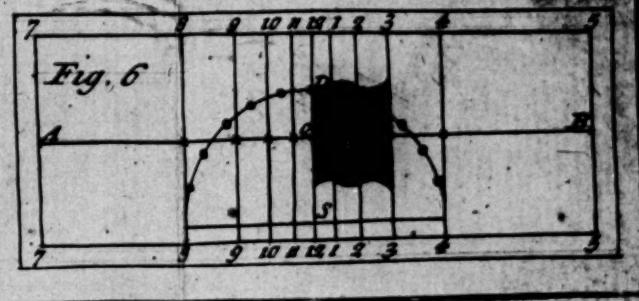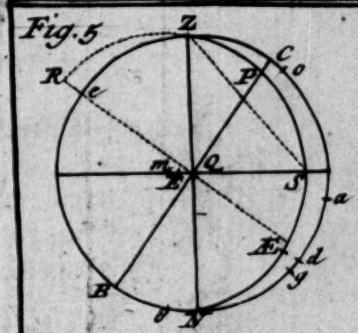
Fig. 6
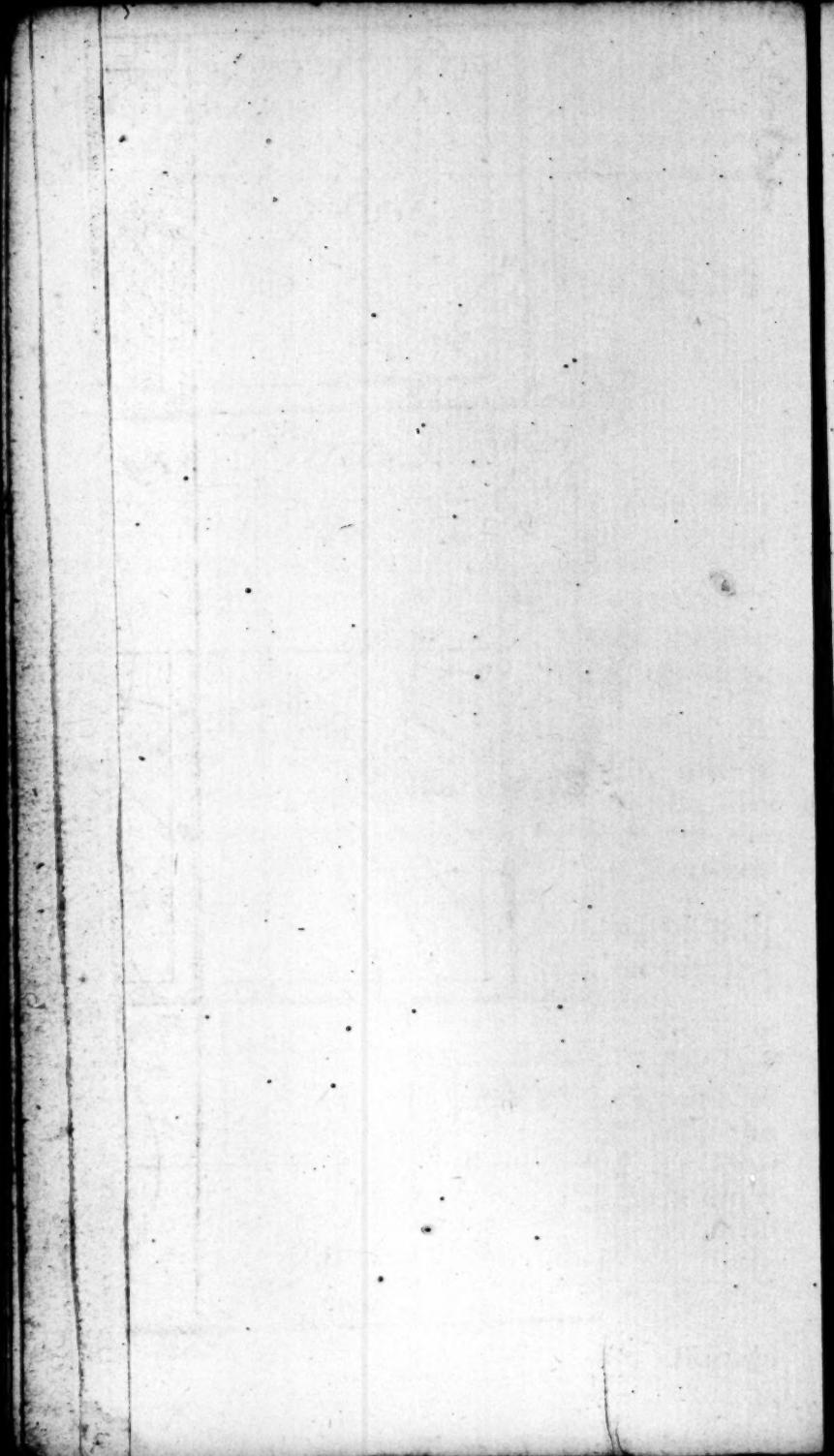
Fourthly, Becaufe the *Pole* of the World is always diftant from the Zenith, the Complement of the Latitude of the place, *viz.* here at *London*, 38 deg. 28 min. Take therefore 38 deg. 28 min. out of your Line of Chords, and fet them upon your Plain from *a*, the point which found the Zenith to C.

Fifthly, Lay a Ruler from W to C, and it will cut the Meridian D Q R, (being thus extended) in *P*, fo is *P* the North Pole of the World, and becaufe it falleth without the *Plain*, it is evident by the Scheme, that this reclining *Plain* paffeth through the Meridian, between the Zenith and the Pole. And again, becaufe the North Pole *P* falleth without the *Plain*, it alfo demonftrates, that the South Pole muft be elevated above this Plain. Wherefore,

Sixthly, To find the point of the South Pole upon the Meridian Line D Q R, do thus. Becaufe the two Poles are 180 deg. diftant from each other, *viz.* two Quadrants, or twice 90 deg. Take therefore 90 deg. out of your Line of Chords, and fet them twice upon your *Plain* from C, *viz.* firft from C to *e*, and then from *e* to *n*, fo fhall the 180 deg. end in *n* : And a Ruler being laid from W to *n*, fhall crofs the Meridian in A, the South Pole ; fo is the South Pole A elevated above the Reclining Plain, the Quantity of A R, which is equal to the Arch R *n*, which meafured upon the Line of Chords, will be found 13 deg. 28 min.

Seventhly, Lay a Ruler from W to *e*, and it will cut the Meridian in Æ, fo is Æ that point in the Meridian, through which the Æquinoctial muft pafs. As alfo through the points E and W, the Eaft and Weft points of the Horizon.

G 3 *Eighthly,*

Eighthly, For the Hour-lines, They are to be
drawn in all refpects as the Hour-lines were up-
on the upright South Plain, without any Altera-
tion, only there the Stile was elevated accord-
ing to the Complement of the Latitude 38 deg.
28 min. here it muft be elevated only 13 deg.
28 min. as in the Scheme. The manner how
the Hour-lines are to be put on, I fhall only re-
peat; but I fhall forbear drawing them, leaving
that to your own Practice, in regard there is no
Alteration at all from the Erect Direct South
Plain. Wherefore divide the Semicircle of your
Plain W R E into 12 equal parts, (beginning at
R, and fo 6 equal parts on either Side of the
Meridian D Q R.) Then lay a Ruler to Q,
and every of thofe 12 Divifions, it will divide
the Æquinoctial into 12 unequal parts. A Ru-
ler laid from P to every of thofe unequal parts
in the Æquinoctial, will divide the Plain into
12 other unequal parts, through which laft 12
unequal parts, and the Center Q, if you draw
right Lines, they fhall be the true Hour-lines
proper for the *Plain.*

And here by the way note, for that the Æ-
quinoctial Circle in this Scheme is a very ob-
lique Arch, the Center of it will be ve-
ry remote, and the Hour-fpaces upon it
(as alfo upon the *Plain*) will be very clofe
together in thefe fmall Draughts, which is
occafioned by the fmall Elevation that the
South *Pole* hath above this Plain, *viz.* but
13 deg. 28 min. which you might find
without drawing of the Scheme, by fub-
tracting 25 deg. the *Plain's* Declination, re-
prefented in the Scheme by the Line (or
Circle) D Z, from Z P, the Complement of
the

the Latitude of the place. And therefore, foreseeing that the Pole hath but small Elevation above the Plain, and also what *Pole* whether North or South thi is elevated : The better way will be to augment the S:ile, and to draw the *Dial* according to these following Directions.

How to draw the Hour-lines upon the Plain.

In the Scheme following, draw, *First*, The right Line W Q E, for the *Horizontal*, and *Perpendicular* thereunto, in the Line S Q R, for the Meridian and Hour-line of 12, which extend above the Horizontal Line to S.

Secondly, Upon S as a Center, with 60 deg. of your Chord, describe a small Arch of a Circle, and upon it set 13 deg. 28 min. the Height of the *South Reclining* Pole above the Plain from A *25 Deg. Plate* to B, and draw the Line S B *4. Fig. 4.* for the Stile.

Thirdly, At any convenient Distance, answerable to the Largeness of your Plain, draw a Line parallel to W E, as the Line C D F.

Fourthly, Set one Foot of your Compasses in D, and with the other take the nearest Distance to the Stile S B, which Distance set upon the Meridian from D to H.

Fifthly, Upon the point H, (your Compasses opened to 60 deg. of your Line of Chords) describe the Semicircle K Q L, which divide into 12 equal parts in the points ⊙ ⊙ ⊙, *&c.*

Sixthly, Lay a Ruler unto H, and upon every of the points ⊙ ⊙ ⊙, *&c.* and it shall cut the Æquinoctial Line C D F, in the points * * *, *&c.* through which the Hour-lines must pass ;

Where

Wherefore, if from the Center S, and through the several points *** , &c. in the Line C D F, you draw strait Lines, bounding them between any two Lines as W E, and M N, they shall be the true Hour-lines. Or,

Seventhly, If you draw another Tangent Line, and describe another Semicircle, and divide it, and the other Line, as you did the former, so shall the Lines drawn through the respective points ** * , &c. in either of the Æquinoctial (or Tangent Lines) be the true Hour-lines belonging to the Plain, without any Regard had to the Center at all, as you before did in Upright far Decliners.

The Third Variety.

C H A P. XIV.

How to draw the Hour-lines *upon a* Direct South Reclining Plain, *which passeth between the* Pole *and the* Horizon.

Let the Example be of a South Plain, Reclining 55 deg. in the Latitude of *London,* 51 deg. 32 min.

FIRST, Draw the Circle W N E R, for your Reclining Plain, cross it with two Diameters N Q R, the Meridian, and W K E, the Horizontal Line of the *Plain.*

Secondly, Take 55 deg. the *Plain's* Reclination, out of your Line of Chords, and set that Distance from N to *a*, and from E to *b*.

Thirdly,

Thirdly, Lay a Ruler from W to *a,* it will cut the Meridian in Z, so is Z the *zenith* of the place, through which, and the points W and E, draw the prime Vertical Circle W Z E.

Fourthly, Lay a Ruler from W to *b,* and it will cut the Meridian in S, the South point of the *Horizon,* through which and the points W and E, the Horizon of the place W S E muſt be drawn.

Fifthly, The Pole being diſtant from the *zenith* of the place 38 deg. 28 min. equal to the Com-plement of the Latitude, ſet 38 deg. 28 min. from *a* to C, and a Ruler laid from W to C, ſhall cut the Meridian in *P,* the Pole of the World, and 90 deg. of your Line of Chords being ſet from C to *n,* and a Ruler laid from W to *n,* ſhall cut the Meridian in Æ through which, and the points W and E muſt the Æquinoctial Circle be deſcribed : The Center whereof, as alſo of the Horizon and prime Vertical Circles are all in the Meridian N Q R, extended where need re-quires, and how theſe Centers are to be found, is ſhewed already.

Sixthly, For the drawing of the Hour-lines, they muſt be drawn as in the Erect Direct South Plain, or as was directed in the laſt Plain, and ſo I ſhall ſay no more of them in this place ; only take Notice, that the North Pole is elevated above this *Plain,* the Quantity of the Arch N C, which is 16 deg. 32. min.

These are the three Varieties of South Direct Reclining Plains, and in the making of these you have alſo made the oppoſite Incliners as much, for each Plain hath two Faces, the one open to the *zenith,* and the other to the *Nadir* of the Place.
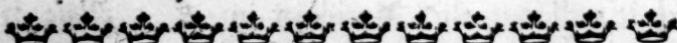
III. Of

III.   *Of North Direct Recliners.*

CHAP. XV.

How to draw the Hour-lines *upon a* Direct North
Reclining *Plain.*

AS in *South Reclining Plains* there were three
Varieties, so also are there as many in the
North Recliners; For,

1. The North Plain may so recline, that it
may pass through the Meridian, juſt at the In-
terſection of the Meridian with the Æquinoctial,
the *Plain* it ſelf lying in the Æquinoctial Circle,
and the Poles thereof in the Poles of the World,
and ſo it is called, *A Polar Plain.* Or,

2. The *Plain* may so Recline, that it may cut
the Meridian between the *Zenith* and the Æqui-
noctial. Or,

3. It may recline so far, as to cut the Me-
ridian between the Equinoctial and the Ho-
rizon.

Examples of theſe three Varieties of North
Reclining Plains follow :

Fig. 1.

Fig. 2.

Fig. 3.

Plate 4.

Fig. 4.

Fig. 5.

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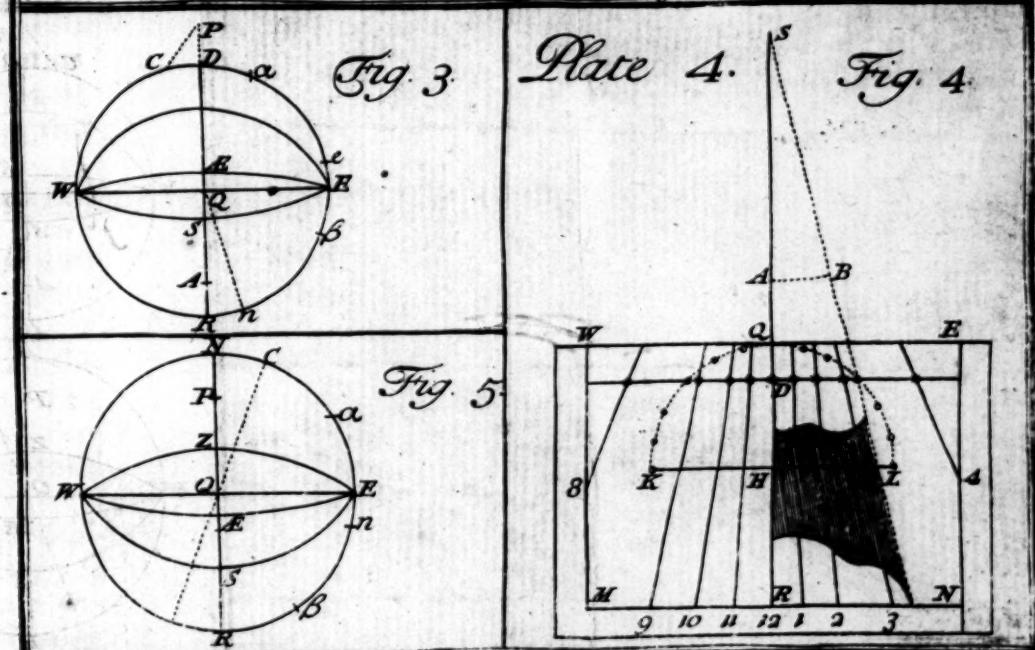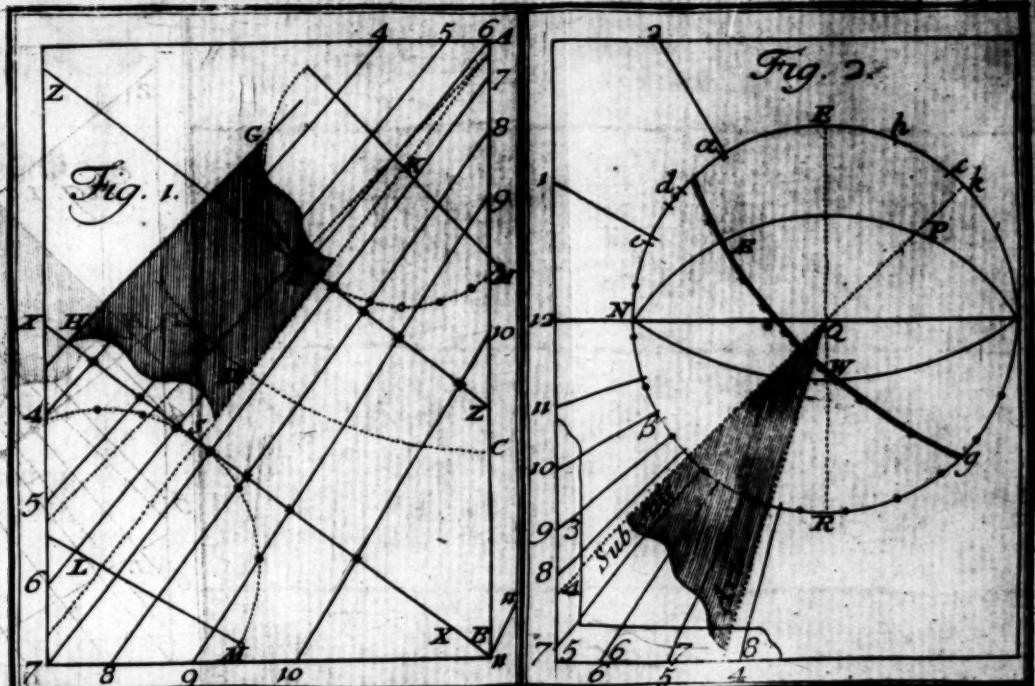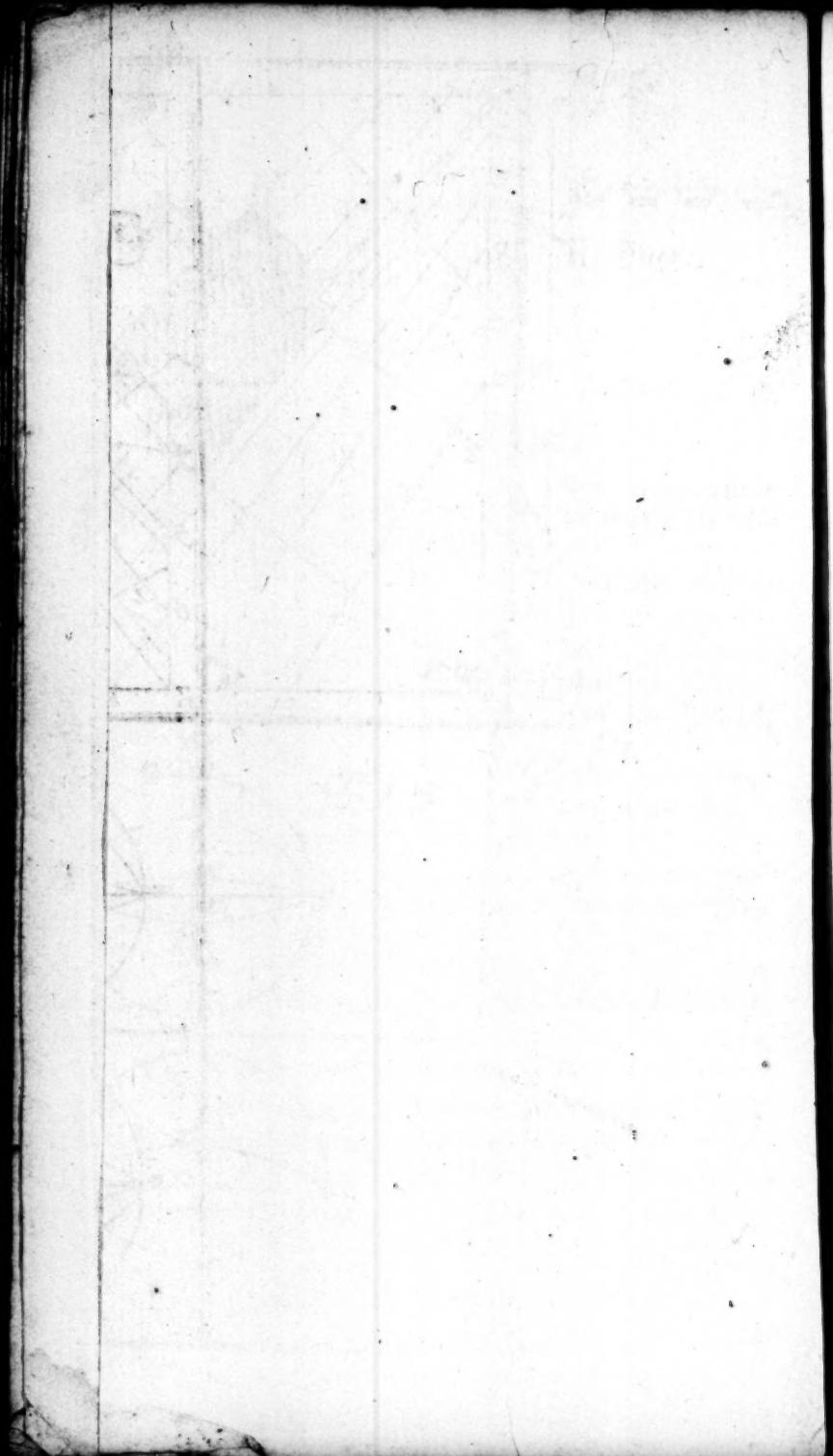
The First Variety.

CHAP. XVI.

How to draw the Hour-lines upon a Direct Polar
Plain, *which Reclineth just to the* Æquinoctial.

Example of a North Plain, Reclining 51 deg.
32 min. equal to the Latitude of the place,
viz. London.

FIRST, Describe the Circle E Æ W R, for
your *Plain*, cross it with the Diameters Æ Q
R, for the Meridian, and W Q E for the prime
Vertical Circle.

Secondly, Set 51 deg. 32 min. the Reclination
of the *Plain*, (which in this Example is also equal
to the Latitude of the Place) from Æ to *a*, and
also from W to *b*.

Thirdly, A Ruler laid from E to *a*, will cut the
North part of the Meridian in Z the *Zenith*
of the place, and being laid from E to *b*, it will
cut the Meridian in N, so is N the North point
of the *Horizon*.

Fourthly, Through the points W, Z and E, (by
former Direction) draw the prime Vertical Cir-
cle, or Azimuth of East or West, W Z E. And
also through W, N and E, draw the Horizontal
Circle W N E.

Fifthly, Because the Pole of the World is al-
ways removed from the Zenith of the Place, so
much as is the Complement of the Latitude (in
this Example 38 deg. 28 min.) Set 38 deg.

28

28 min. from *a*, (the point in the *Plain*, which found the Zenith point Z,) Northward of the Zenith, and the Compaſs-point will fall in W, the Weſt point of the Horizon ; ſo that if a Ruler were laid from W to E, it would cut the Meridian in Q, for the Pole of the World, which is already the Center of the Plain, ſo that the Pole of the World, and the Pole of the Plain, fall both in one point, and the Pole Q is elevated above the Plain 90 deg. *viz.*

A Direct Polar
North Dial. Pl.
5. Fig. 1.
the Quantity of the Meridian Line Æ Q, or rather the Arch Æ W, which is the Meaſure thereof.

Sixthly, To draw the Hours upon this Plain, it is eaſieſt of all others, for if you divide the Semicircle E R W, into 12 equal parts in the points ☉ ☉ ☉, *&c.* and through thoſe points draw ſtrait Lines from the Center Q, they ſhall be the true Hour-lines belonging to this *Polar Plain.*

And this Plain, by reaſon of its North Reclination, is, in Summer, capable of receiving all the Hours from Sun-riſing to Sun-ſetting, and therefore the Hour-lines of 4 and 5 in the Morning, and of 7 and 8 at Night, muſt be drawn through the Center, as you did in the Vertical or Horizontal Dial, and as you ſee here done in this Figure.

The Stile of this Dial muſt be a ſtrait Pin or Wire, ſet perpendicular upon the Plain, from the Centre Q, and of any Length. And this for the firſt Variety of North Recliners.

The South Inclining Plain oppoſite to this, is directly the ſame, only the Forenoon Hours in this muſt be the Afternoon Hours in that, and the

the Hours of 4 and 5 in the Morning, and of 7 and 8 in the Evening, muſt be omitted.

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The Second Variety.

C H A P. XVII.

How to draw the Hour-lines upon a North Reclining *Plain, which interſects the Meridian between the Zenith and the Æquinoctial.*

Let the Example be of a North Plain, Reclining 25 deg.

FIRST, Draw the Circle E S W R, repreſenting your North *Reclining Plain,* and croſs it with the two Diameters S Q R, the Meridian of the Place, and E Q W, the *Horizontal* Line of the Place.

Secondly, Set the *Reclination* of the *Plain* 25 deg. from S to *a,* and from W to *b.*

Thirdly, Lay a Ruler from E to *a,* it will cut the Meridian in Z the Zenith. And a Ruler laid from E to *b,* will cut the Meridian in N the North point of the Horizon : So have you three points E Z and W, whereby to draw the prime Vertical Circle E Z W; and three points alſo, *viz.* E N and W, whereby to draw the Horizon E N W.

Fourthly, Becauſe the Æquinoctial is always 90 deg. diſtant from either of the *Poles,* ſet 90 deg. upon your *Plain,* from *c* to *d.* Then laying a Ruler to E and *d,* it will cut the Meridian in Æ, ſo is Æ the point of the Interſection of the Æquinoctial, with the North part of the

H Me-

Meridian ; wherefore through the points E Æ
W, defcribe the Æquinoctial Cir-
Plate 5. cle ; the Center whereof, as alfo of
Fig. 2. the Horizon, and prime Vertical Cir-
cle, will fall in the Meridian S Q R,
extended where need requires.

Fifthly, The *Horizon, Æquinoctial,* and *Pole,*
being thus feated in their true Pofitions upon
the *Plain,* the Thing required in this Dial, is,
The Height of the Pole above the Plain, which may
be found in this Manner.—— Lay a Ruler from
E to P, and it will cut the *Plain* in *c,* the Di-
ftance S *c,* meafured upon your Line of Chords,
will contain 63 deg. 28 m. which is the Height
of the *Pole* above the *Reclining Plain.*

Laftly, For the drawing of the Hours, that is
done the fame way as in the Erect Direct South
Plain, only here the *Stile* muft be elevated above
the *Meridian Line* 63 deg. 28 min. whereas
there it was only 38 deg. 28 min. the Comple-
ment of the Latitude. The North *Pole* is ele-
vated above this *Plain,* and the Hours that the
Plain is capable to receive, are 4, 5, 6, 7, 8,
and 9 in the Morning, and 3, 4, 5, 6, 7, and 8
at Night.

The Height of the *Pole* (or *Stile*) above this
Plain may be found by adding the Comple-
ment of the Latitude 38 deg. 28 min. and
25 deg. the Reclination together, the Sum
whereof is 63 deg. 28 min. the Height of
the Stile, as before.

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The Third Variety.

CHAP. XVIII.

How to draw the Hour-lines upon a Direct North Re-
clining Plain, which intersects the Meridian between
the Æquinoctial and the Horizon.

Let the Example be of a Direct North Plain,
Reclining 70 deg. in the Latitude of *London*,
51 deg. 32 min. Plate 5. Fig. 3.

FIRST, Draw the Circle E S W R, represen-
ting your North Reclining *Plain,* and cross it
with the two Diameters S Q R, for the Meridian
of the Place, and with E Q W the Horizontal
Line of the *Plain.*

Secondly, Set the Reclination of the *Plain* 70
deg. from S to *a,* and from W to *b.*

Thirdly, Lay a Ruler to E and *a,* it will cut
the Meridian in Z the Zenith, through which,
and the points E and W, draw the prime Verti-
cal Circle E Z W.——— Also, lay a Ruler from
E to *b,* it will cut the Meridian in N, the Inter-
section of the Meridian with the North part of
the Horizon, now through the points E N and
W, describe the Horizon of the place E N W.

Fourthly, Forasmuch as the Pole is distant
from the Zenith of the Place 38 deg. 28 min.
(equal to the Complement of the Latitude) set
38 deg. 28 min. from *a,* the point which gave
the Zenith Z to *c,* and lay a Ruler from *e* to *c,*

H 2   ſo

fo fhall it crofs the Meridian in *P*, the Pole of the World.

Fifthly, Becaufe the Æquinoctial is in all Places fituate 90 deg. from either Pole. Take 90 deg. in your Compaffes, and fet them off from *c*, (the point which gave the Pole *P*) both ways, to *e* above, and to *g* below. So a Ruler laid from E to *g*, will cut the Meridian (it being extended) in Æ, without the Plain, which fhews that the North part of the *Æquinoctial Circle* lies below this *Plain*. Therefore lay a Ruler from E to *e*, and it will crofs the Meridian in Æ above, So is Æ the point where the Meridian, and the South point of the *Æquinoctial* will interfect, and through that point and the points E and W, muft the *Æquinoctial* E Æ W, be drawn.

Sixthly, The *Horizon, Pole*, and *Æquinoctial*, being thus projected, the Thing required in this Plain, is, *The Height of the Pole above it*, viz. P R. which may be found in this manner.—— Lay a Ruler from E to *P*, and it will cut the Plain in *c*, the Diftance from R to *c* meafured upon the Chord, will be 71 deg. 32 min. which is the Height of the Pole above this Reclining Plain.— Or the Height of the Pole above the Plain may be found, by adding the Plain's Reclination 70 deg. to 38 deg. 28 min. the Complement of the Latitude, the Summ whereof 108 deg. 28 min. which taken from 180 deg. the Remainder will be 71 deg. 32 min. as before.

Laftly, For the drawing of the Hour-lines, they are done in all refpects as thofe before in South Erect Plains, only in this make the Elevation of the Stile 71 deg. 32 min. as you find it by your Projection.

Your Hour-lines being drawn, erect the *Stile* 71 deg. 32 min. above the Meridian or Subftile,

letting

letting it point up to the North Pole, becaufe that Pole above this Plain is fo much elevated, and being this Plain is but 20 deg. raifed above the Horizon, *viz.* the Complement of his *Recli-nation*, the Plain is capable to receive all the Hours from 4 in the Morning to 8 at Night, and therefore the Hours   *Plate* 5. of 4 and 5 in the Morning, and 7   *Fig.* 3. and 8 in the Evening, muft be drawn through the Center, as was done in the *Vertical* or *Horizontal Dial.*

And thus have you had Examples of all the Varieties both of *Eaft, Weft, North,* and *South Reclining* Plains ; and no other can pof-fibly fall out in any place whatfoever. The Inclining Plains are the fame with the *Re-cliners* oppofite to them ; and muft be drawn in the fame manner as hath been (in fome Meafure) heretofore hinted, and fhall be more at large difcourfed of hereafter, when I have done with *Declining Reclining* Plains, of which I come now to treat.

IV. *Of Declining Reclining Plains.*

CHAP. XIX.

AS there were fix Varieties of Direct North and South Reclining Plains, fo alfo are there of South and North Declining Reclining Plains, *viz.* Three Varieties of South *Recliners Declining*, and as many of North *Recliners Declining*. For in South *Recliners Declining*,

1. The *Declination* may be such, that the South *Reclining Plain* may cut or fall upon the Meridian, just upon the Pole point; and such *Reclining Declining Plains*, are called *Æquinoctial Decliners* : Or,

2. The *Declination* may be such, that the *Reclining Plain* shall intersect the Meridian between the Zenith of the Place, and the Pole of the World : Or,

3. The *Declination* may be such, that the *Reclining Plain* shall cross the Meridian between the Pole and the Horizon.

These are the three Varieties of South Recliners *Declining. In* North Recliners Declining *there are three other Varieties. For,*

1. The *Declination* may be such, that the North Reclining Plain may cross the Meridian in the point where the *Æquinoctial* intersects the Meridian. And then such Plains are called Polar Declining Plains, because the Poles of them lie in the *Axis of the World*, and the *Substile* in such Plains will be always perpendicular to the Meridian of the place.

2. The *Declination* may be such, that the Reclining Plain may intersect the Meridian, between the *Zenith*, and the *Æquinoctial* : Or,

3. The *Declination* may be so much, that the Reclining Plain may fall upon the Meridian, between the *Æquinoctial* and the *Horizon*.

Examples of all these Varieties follow.

I. Of *South Recliners*.

The First Variety.

CHAP. XX.

How to draw the Hour-lines upon a South Reclining
Declining Plain, which cutteth the Meridian in the
Pole Point.

IN Declining Reclining Dials, before the Hour-
lines can be drawn, Three Things must be
given, and Four Things found : The Things
given, are,

Given {
1. The Latitude of the place.
2. The Declination of the Plain.
3. The Plain's Reclination.
}

The Things required, are,

Required {
1. The Distance of the Meridian and Horizon.
2. The Height of the Pole above the Plain.
3. The Distance of the Substile and Meridian.
4. The Plain's Difference of Longitude.
}

Ln

*Let the Example be of a South Plain Declining East,
30 d. and Reclining 34 deg. 32 min. in the La-
titude of* London, 51 *deg.* 32 *min.*

First, Draw the Circle H A O R, and cross it
with the two Diameters H Q O, the
Horizontal Line of the *Plain,* and A
Q R, the perpendicular Line of the
Plain, crossing each other at right An-
gles in Q, the Center of the *Plain.*

· Plate 5.
Fig. 4.

Secondly, Because the *Plain* reclined 34 deg. 32
min. Take 34 deg. 32 min. from your Line of
Chords, and set them upon your *Plain* from A to
a, from H to *b,* and from R to *c.*

Thirdly, Lay a Ruler from O to *a,* and it will
cut the perpendicular Line of the *Plain* in Z the
Zenith of the Place. Also a Ruler laid from O
to *b,* will cut the *Plain's* Perpendicular in K, the
Intersection of the Horizon of the place, with
the *Plain's* Perpendicular. And a Ruler laid
from O to *c,* will cut the perpendicular of the
Plain A R, (it being extended) in N the Nadir
point. Having found these points upon the per-
pendicular Line of the *Plain.*

Fourthly, Through the points H K O, draw
the Horizon of the place. And,

Fifthly, Because the *Plain* declines. 30 deg.
Eastward, take 30 deg. out of your Chord, and
set them from R to *d,* and from O to *e;* and
laying a Ruler from Z the Zenith to *e,* it will
cross the Horizon in E, the East point thereof,
and the Ruler laid from Z to *d,* will cross the
Horizon in S the South point thereof, so have
you found three points, *viz.* Z N and S, through
which you may draw the Meridian, whose Cen-
ter

ter you may find, as hath been before taught :
Or in this manner ;

Divide the Space between Z and N in two e-
qual parts in C, and through C draw the Line
C D parallel to Q O, extending it as you
shall have Occasion. Also from Q, through
E, draw another Right Line Q E, extending
it, as Occasion shall offer ; the point of
those two Lines Interfection is the Center
of the Meridian. Which being drawn,

Sixthly, Lay a Ruler from E the East point of
the Horizon to Z the Zenith, and it will cut the
Plain in *h*. And because the Pole of the World
is distant from the Zenith 38 deg. 28 min. equal
to the Complement of the Latitude, set 38 deg.
28 min. from *h* upon the *Plain*, and it will fall
just upon *P*, which is the point of the *Plain's* In-
terfection with the Meridian, which demonstrates
the Pole to have no Elevation above the *Plain*,
and so the *Plain* to be *Æquinoctial Declining.*

Seventhly, Draw the Line P Q L for the Axis
of the World, and because the Æquinoctial
Circle is in all parts distant from either Pole 90
deg. set 90 deg. from P or L, to Æ ; and
through Q, draw the Line Æ Qæ, for the Æ-
quinoctial Circle, which is here a strait Line,
and being extended, would pass through the
Center of the Meridian, and also through the
East and West Points of the Horizon, as it ought
to do.

The Scheme being thus projected, the four
Requisites from it are easily obtained. For,

1. *To find the Distance of the Meridian, and the
Horizon* O P. The Arch O P measured upon
<div align="right">your</div>

your Line of Chords, will contain 71 deg. 53 min. the Distance required.

2. *The Height of the Pole above the Plain* (the point P) 00 deg. 00 min. therefore it is an Æquinoctial Declining Plain.

3. *The Distance of the Substile and the Meridian,* the point P also. Therefore that, as also all the Hours, must be parallel to the Substile.

4. *To find the Plain's Difference of Longitude,* Q P B. Lay a Ruler from P to B, and it will cut the *Plain* in *m*, the Distance L M measured upon your Chord, is the *Plain's* Difference of Longitude 24 deg. 19 min.

These Requisites being thus found, I will now shew.

How the Hour-lines are to be drawn upon the Plain.

First, Draw a Line, as B A C for the Horizontal Line of your *Plain,* and upon any convenient point therein, as upon A, with 60 deg. or the Radius of your Line of Chords, describe the Semicircle B D C.

Secondly, From your Line of Chords take 71 deg. 53 min. the Distance of the Meridian and Horizon, and set them from B to D, and draw the Line A D for the Substile.

Thirdly, Take 24 deg. 19 min. the *Plain's* Difference of Longitude, and that Distance from D to E, and draw the Line A E.

Fourthly. Divide the Semi-Circle B C D into 12 equal parts at the points ☉ ☉ ☉, &c. beginning the Division at the point E.

A South Plain declining East 30 d.
reclining 34 d. 32. Pl. 5. Fig. 5.

Fifthly,

Fifthly, Through the point O, (or any other point taken at all Adventures in the Subſtilar Line) draw a Line M O N at right Angles, (or perpendicular) to the Subſtilar, repreſenting the Æquinoƈtial.

Sixthly, Lay a Ruler from A, and every of the points ◉ ◉ ◉, *&c.* in the Semicircle, and it will croſs the Equinoƈtial in the points * * *, *&c.*

Laſtly, If through theſe points * * * *&c.* you draw right Lines parallel to the Subſtilar, they ſhall be the true Hour-lines belonging to your *Plain,* the Hour-line of 12 being that where you began to divide your Semicircle, that is, at the Mark (or *) which was made from the point E.

For the Stile of this Dial, it may be either a ſtrait Pin or Wire, of the juſt Length of the Line A O, erected perpendicularly upon ſome point of the Subſtile (as at A or O) the very Top of the Shadow thereof, giving the Hour among the Hour-lines upon the Dial.

Or elſe the Stile may be a Plate of Braſs or Iron of the Breadth of A O, ſet perpendicular to the *Plain,* upon the Subſtilar Line A O D, the Shadow of whoſe upper Edge ſhall give the true Hour of the Day.

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The Second Variety.

C H A P. XXI.

How to draw the Hour-lines upon a South Reclining Plain, Declining East or West, which passeth between the Zenith and the Pole.

IN this, as in all other Decliners Reclining, three Things must be known, and four must be found before the Drawing of the Hour-lines.

Let the Example be a South Reclining Plain, Declining East 30 deg. and Reclining 20 deg. in the Latitude of 51 deg. 32 min. London.

Given
$\begin{cases} \text{1. Latitude of the place} & 51 \quad 32 \\ \text{2. Declination South East} & 30 \quad 00 \\ \text{3. Reclining South} & 20 \quad 00 \end{cases}$

Required
$\begin{cases} \text{1. The Distance of the Meridian and Horizon.} \\ \text{2. The Height of the Pole above the Plain.} \\ \text{3. The Distance of the Substile and the Meridian.} \\ \text{4. The Plain's Difference of Longitude.} \end{cases}$

First,

First, Defcribe the *Circle* H A O R, reprefen-
ting your *Reclining Declining Plain,* and crofs it at
right *Angles,* with the two Diameters A R, for the
perpendicular, and H O for the Horizontal Line
of the Plain.

Secondly, Take 20 deg. the Plain's
Reclination, out of your Chord, and *Plate* 5.
fet them from A to *a,* from O to *b,* *Fig.* 6.
and from R to *c.*

Thirdly, A Ruler laid from H to *a,* will give
you Z the Zenith, and laid from H to *b,* will give
you K the Interfection of the Horizon with the
perpendicular Line of the Plain. And the Ru-
ler laid from H to *c,* will give you N the Nadir,
then through the Points H, K and O, draw the
Horizon H K O.

Fourthly, Take 30 deg. the Plain's Declina-
nation out of your Line of Chords, and fet them
from R to *d* weftward, (becaufe the Plain declines
Eaftward) and alfo from O to *e,* fo a Ruler be-
ing laid from Z to *e,* fhall cut the Horizon in E,
the Eaft point thereof, and laid from Z to *d,*
fhall cut the Horizon in S, the South point
thereof. Thus have you three points Z, S and
N, through which to draw the Meridian Circle,
which you may extend without the Plain to
P and N, occafion fometimes requiring it fhould
be fo.

Fifthly, Forafmuch as the Pole of the World
is always diftant from the Zenith, equal to the
Complement of the Latitude of the place, as
here at *London,* 38 deg. 28 min. Lay a Ruler
from E to Z, and it will cut the Plain in *h,* from
whence fet 38 deg. 28 min. to *k.* So a Ruler
laid from E to *k,* will cut the Meridian (exten-
ded) in the point P, the North pole of the
World. And a Ruler laid from P to Q. fhall

I   crofs

crofs the Meridian in L, the South-pole, and the Line P Q L, fhall be the Axis of the World.

Sixthly, Take 90 deg. of your Chords, and fet them from *k* (the point which found the pole at P) to *n* : So a Ruler laid from E to *n*, fhall cut the Meridian in B, through which point, and through the point E, the *Æquinoctial Circle* muft be defcribed, whofe Center will be in the Axis P L extended, and the manner how to find it, hath been feveral Times already difcovered.

The *Horizon, Meridian,* and *Æquinoctial Circles* being thus defcribed upon your Plain, by their Interfections, and Diftances, the four Requifites belonging to this *Declining Reclining Plain* may be obtained. As, •

1. To find the Diftance of the Meridian and Horizon H V. The Diftance H V upon the Plain, meafured upon the Line of Chords, will contain 78 deg. 50 min. the Diftance of the Meridian and Horizon.

2. To find the Height of the Pole or Stile, above the Plain L c. Set 90 deg. from *c* to *b*, then lay a Ruler from *b* to L, and it will cut the plain at *m*, the Diftance from *c* to *m*, meafured upon your Chords, will contain 13 deg. 40 min. the Height of the *Pole* or *Stile* above the plain.

3. To find the Diftance of the Subftile from the Meridian *V c,* meafure the Diftance *V c* upon the Line of Chords, and it will contain 7 deg. 30 min. the Diftance required.

4. To find the Plain's Difference of Longitude, B L D. Lay a Ruler from L to B, it will cut the plain in *h,* fo the Diftance *h* O meafured upon the Line of Chords, will contain

tain 28 deg. 52 min. the plain's Difference
of Longitude.

Thus are the four Requifites belonging to this
Plain found, and in this Example, two Things
are very obfervable.

1. Whereas P the North pole of the World,
falls without the *Plain*, and the point L,
reprefenting the South Pole falls within the
Plain, it denotes that the South pole muft
be elevated.

2. In refpect that the Line or Arch L *e* which
is the Height of the Stile or Pole above the
Plain, is but of fmall Quantity, *viz.* 13 deg.
40 min. it will from thence follow, that the
Æquinoctial Centre will be very remote, and
that the Hour-lines near to the Subftile will
be very clofe, fo that in fmall *Dials* their
Diftances one from another will be infenfible;
and therefore you may fave the Labour of
defcribing the *Æquinoctial Circle*, and be fa-
tisfied in finding of the point B, by which
the *Plain's* Difference of Longitude is found.
For, in fuch Cafes as this, the *Plain's* Dif-
ference of Longitude, the Diftance of the
Meridian from the Horizon, and of the
Subftile's Diftance from the Meridian, and
the Height of the *Pole* above the *Plain* being
gained, you may proceed to draw the *Dial*
as followeth, not much differing from the
drawing of the Upright far declining *Dial*
Chapter VIII.

I 2   *How*

How to draw the Hour-lines upon the Plain.

First, Draw a right Line A B C for the *Horizontal* Line of your *Plain*, and affume any convenient place therein, as B for a Center ; upon which point, with 60 deg. of any large Line of Chords, (*For it is neceffary, not only in this, but for divers others Occafions, to have feveral Lines or Scales of Chords upon your Ruler, or elfe ufe a Sector, which fupplies them all)* defcribe the Arch of the Circle A D. Upon this Arch, from A to D, fet 78 deg. 50 min. the Diftance of the Meridian from the Horizon, and note the point E, but you need not draw the Meridian Line.

South Declining Eaft 30 deg. Reclining 20 deg. Plate 5. Fig. 7.

Secondly, From D to E fet 7 deg. 30 min. the Diftance of the Subftile from the Meridian, the fame way as you find it to lie in your Projection, and draw the Line B E for the Subftile. Alfo upon the fame Arch, fet off 13 deg. 40 min. the Height of the Stile from E to F, and draw the Line B F for the Stile. Which being but of fmall Elevation, *viz.* 13 deg. 40 min. ought to be augmented ; and therefore (at any convenient Diftance fuitable to the Bignefs of your Dial-plain) draw a Line as G H, parallel to B F, for your augmented Stile or Axis.

Thirdly, Through any two points taken at Adventure, in the Subftilar Line, as K and L, draw two right Lines perpendicular, or at right Angles to the Subftilar, as the Lines M K N, and O L P. Then from the point K, take the leaft Diftance to the augmented Stile G H, and fet that Diftance upon the Subftilar K to Q. Alfo

Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
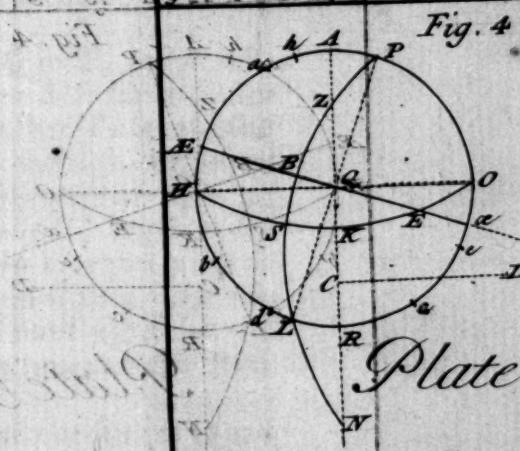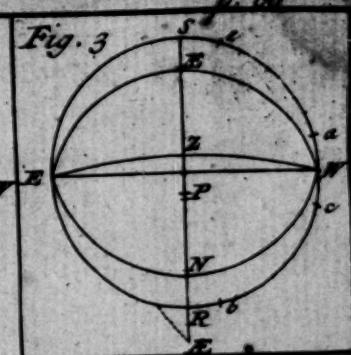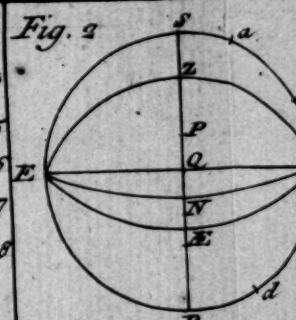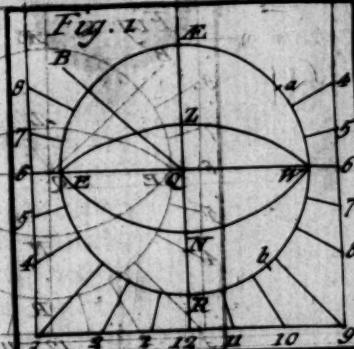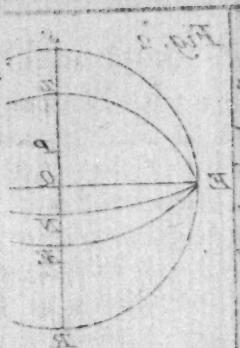
Plate 5.
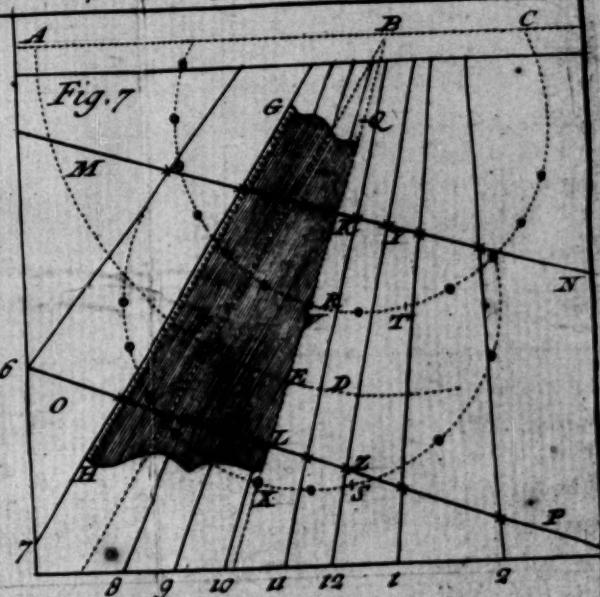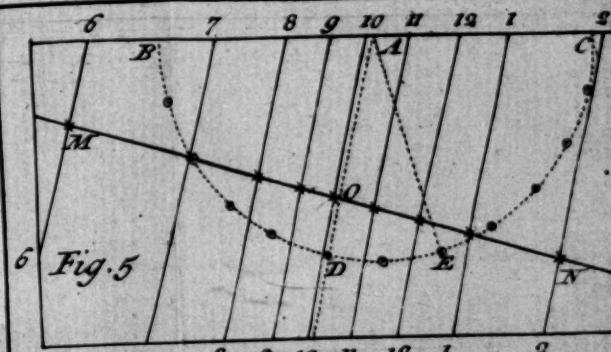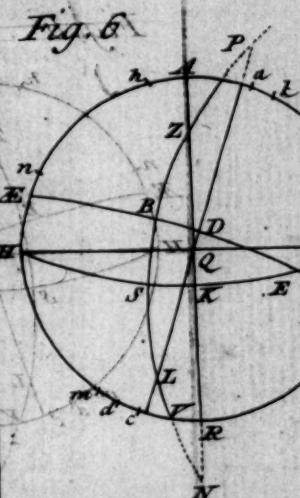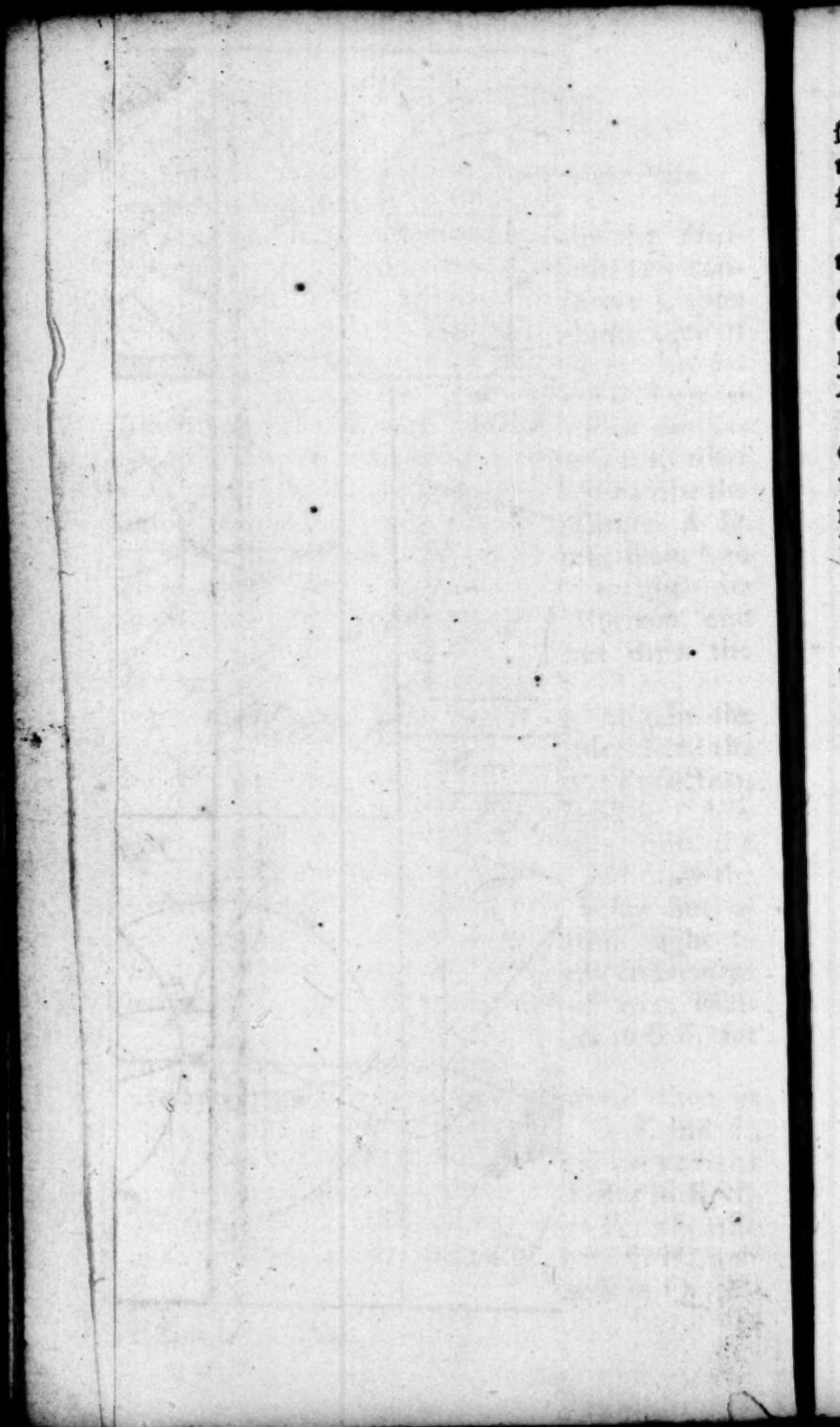
fo from the point L, take the nearest Diſtance to the augmented Stile G H, and ſet that Diſtance upon the Subſtilar from L to R.

Fourthly, Upon the points Q and R, as upon two Centers, with 60 deg. of any of your Chords, deſcribe two Semicircles (or other Portions of Circles) and in either of them ſet 28 deg. 52 min. from V to T upon one of them, and from X to S upon the other.

Fifthly, Lay a Ruler from Q to T, and it will cut the Tangent Line in Y: Alſo lay a Ruler from R to S, it will cut the other Tangent Line in Z, and a right Line drawn through the points Y and Z, ſhall be the Hour line of 12.

Sixthly, At the points S and T, begin to divide the ſeveral Semicircles in 12 equal parts or Hours, by taking 15 d. of your Chord, and ſetting them from S and T both ways at the points ⊙ ⊙ ⊙, &c. ſo many times as the *Plain* will receive Hour-lines.

Seventhly, Lay a Ruler from the Points Q and R, to every of the Points ⊙ ⊙ ⊙, &c. in their reſpective Semicircles, and it will croſs their ſeveral Tangent Lines in the points * * *, &c.

Laſtly, Through the points * * *, in both the Tangent Lines, draw right-lines, each to his Correſpondent, which the Hour-line of 12 will direct you how to do, and thoſe ſhall be the true Hour-lines of your *Plain*.

For the Stile of this *Dial*, it may be either of Wire or Plate, containing an Angle equal to the Height of the Pole above the *Plain*, but it muſt be augmented anſwerable to the augmented Stile, as you ſee in the Figure, and muſt be ſet in its proper Place upon the Subſtilar Line, and alſo perpendicular or ſquare to the *Plain*, and ſo is this *Dial* finiſhed.

The

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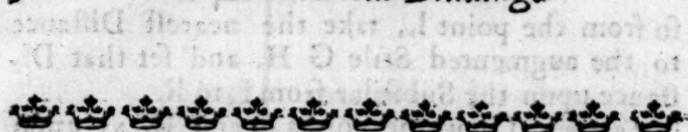
The Third Variety.

C H A P. XXII.

How to draw the Hour-lines upon a South Reclining
*Plain, declining East or West, which interſects the
Meridian between the Pole and the Horizon.*

LET the Example for this third and laſt Va-
riety of South *Declining Reclining Plains,* be
of a South *Plain* declining Eaſtward 30 deg. and
reclining 55 deg. in the Latitude of 51 deg. 32
min. *viz.* London.

		deg.	min.
	The Latitude of the Place	51	32
Given	The Declination Eaſtward	30	00
	The Reclination	55	00

Required
- The Diſtance of the Meridian from the Horizon.
- The Height of the Pole or Stile above the *Plain.*
- The Subſtile's Diſtance from the Meridian.
- The *Plain's* Difference of Longitude.

Firſt, Draw the Circle A H R O, for your re-
clining declining *Plain,* and croſs it with the two
Diameters A R the Vertical, and H O the Hori-
zontal Line of the *Plain.*

Secondly,

Secondly, Set 55 deg. the *Plain's* Reclination from A to *a*, and from O to *b*.

Thirdly, Lay a Ruler from H to *a*, (*Pl.* 2. *Fig.* 5.) and it will give you Z the Zenith, and laid from H to *b*, it will give you K, the point of the Horizon's Intersection with the *Plain's* Vertical Line. So have you three points H K and O, through which to describe the Horizon of the Place H K O.

Fourthly, Set 30 deg. the *Plain's* Declination from R to *c* Westward, (because the *Plain* declines Eastward) and from O to *d*. So a Ruler laid from Z to *c*, shall give you S, the Intersection of the Meridian with the South point of the *Horizon.* And the Ruler laid from Z to *d*, shall give you E the East point of the Horizon.

Fifthly, Having the points S and Z, through them you may draw the Meridian Circle L S Z P, as hath been already several ways taught, the Center whereof will fall in the Line Q E being extended.

Sixthly, Lay a Ruler from E to Z, and it will cut the *Plain* in *e*, from which point *e*, set 38 deg. 28 min. to *f*, and a Ruler being laid from E to *f*, shall give the point P, upon the Meridian Circle for the Pole of the World: And a right Line drawn from P through Q, shall be the Axis of the World, and the Substilar Line of the *Dial.*

Seventhly, Set 90 deg. from *f* to *h*, (because the *Æquinoctial Circle* is in all places 90 deg. distant from either *Pole* P or L.) So laying a Ruler from E to *h*, it will give you the point B in the Meridian, through which, and E, the East point of the Horizon, the *Æquinoctial Circle* must pass, and may be drawn as in former Examples, the

the Center thereof being in the Axis of the World, P L extended.

These three principal Circles, *viz.* the *Horizon*, *Meridian*, and *Æquinoctial*, being describ'd, according to their true Situations upon the *Plain*, the same forementioned Requisites may from thence be easily deduced, as followeth.

1. *To find the Distance of the Meridian from the Horizon* O C. The Arch O C, measured upon the Line of Chords, will contain 64 deg. 41 min. *The Substile's Distance from the Meridian.*

2. *To find the Height of the Pole or Stile above the Plain* P D. Set 90 deg. from D to *æ*, and lay a Ruler from *æ* to P, it will cut the *Plain* in *m*, the Arch D *m* measured on the Line of Chords, will contain 19 deg. 25 m. *The Height of the Stile.*

3. *To find the Substile's Distance from the Meridian* C D. This Arch measured will contain 6 deg. 2 min. *The Distance of the Substile from the Meridian.*

4. *The Plain's Difference of Longitude.* B P Q. A Ruler laid from P to B, will cut the *Plain* in *k*. So the Distance F *k* measured, will be 17 deg. 38 min. *The Plain's Difference of Longitude.*

These Requisites being thus found, you may proceed to draw the Hour-lines in this as in other *Plains.* First, By laying a Ruler upon P the Pole of the World, to B, in the Intersection of the Meridian and Æquinoctial, which will cut the Plain in *k*, at which point, begin to divide the Semicircle into 12 equal Parts. And from Q, to each of them, lay a Ruler crossing the Æquinoctial

quinoctial Circle, and dividing that into 12 un-
equal parts, to which unequal parts of the Æ-
quinoctial, a Ruler laid, it will divide the *Plain*
into 12 other unequal parts, through which, and
the Center Q, right Lines being drawn, they
shall be the true Hour-lines proper for the
Plain.

But in this Example, the Elevation of the
Pole or Stile above the Plain, being but small,
viz. 19 deg. 25 min. you may, if you please,
draw the Hour-lines by one Tangent-line,
and the Center, as was shewed in the se-
cond Variety of Direct South Reclining Plains ;
and as here followeth.

How to draw the Hour-lines upon the Plain.

First, Upon your Plain, towards the Bottom
thereof (because the North pole is here elevated)
draw a right Line A B, parallel to the Horizon,
and assume A for the Center of your Dial, upon
which point, with 60 deg. of your Chords, de-
scribe an Arch of a Circle B E, upon which
from B, set the Distance of the Meridian and
Horizon, 64 deg. 41 min. to C, and draw the
Line A C for the Hour-line of 12. Also, upon
the same Arch from C to D, set 6 deg. 2 min.
the Distance of the Substile from the Meridian ;
and draw the Line A D for the
Substilar. Again, upon the   *A South* Plain
same Arch set off 19 deg. 25   *declining Eastward*
min. the Height of the Stile   *30 deg. and recli-*
from D to E, and draw the   *ning* 55 *deg. Pl.* 6.
Line A E for the Axis of   *Fig.* 1.
the Stile.

Secondly,

Secondly, Upon any part of the Subftilar Line, aſſume any point at pleaſure. As F, through which draw the right Line G F H perpendicular to the Subſtile.

Thirdly, From the point F, take the neareſt Diſtance to the Axis of the Stile, and ſet that Diſtance upon the Subftilar Line from F to O, and upon the point O, with 60 deg. of your Chord deſcribe the Semicircle M L N.

Fourthly, Lay a Ruler from O to K, (the point where the Tangent (or Æquinoctial Line) croſſeth the Meridian) and the Ruler will cut the Semicircle in L, at which point begin to divide it into 12 equal parts in the points ☉ ☉ ☉, &c.

Fifthly, Lay a Ruler from O the Center of the Semicircle to the ſeveral points ☉ ☉ ☉, in the Semicircle, and the Ruler will cut the Tangent Line in the points ** *, &c.

Laſtly, If from the Center A, through theſe points * * *, &c. you draw right Lines, they ſhall be the proper Hour-lines belonging to your Plain.

For the Stile it may be either Plate or Wire, elevated above the Subſtile to an Angle of 19 deg. 25 min. and ſet up perpendicularly upon the Subſtilar, as in all other Dials. And thus have I done with all the Varieties of South Declining Reclining Plains.

II. Of

❀❀❀:❀❀❀❀❀❀❀ ❀❀❀❀❀❀❀:❀❀❀❀

II. Of *North* Recliners.

The *First Variety.*

CHAP. XXIII.

How to draw the Hour-lines *upon a* North Recli-ning Plain, Declining East *or* West, *which cut-teth the* Meridian *at the Intersection thereof with the* Æquinoctial.

L E T the Example be of a North Plain De-clining to the West 60 deg. and Reclining from the Zenith 32 deg. 11 min. in the Latitude of *London* 51 deg. 32 min.

		deg.	min.
	1. Latitude of the place	51	32
Given	2. Declination of the Plain North West.	60	00
	3. Reclining North	32	11

Required

1. The Distance of the Meridian and Horizon.
2. The Height of the Pole or Stile above the Plain.
3. The Distance of the *Substile* and the Meridian.
4. The Plain's Difference of Lon-gitude.

North

	deg.	min.
North { Declining *West*	60	00
{ Reclining	32	11

First, Describe the Circle A H C O for the
          Declining Reclining Plain ; cross it
Plate 6. at right Angles with the two Diame-
Fig. 2.   ters H O for the Horizontal, and A C
          for the Vertical Line of the *Plain.*

And here for Variety, more than for Necessi-
ty, in these three following Examples of
North Recliners Declining, I will (in the feve-
ral Schemes) place the Zenith and Pole
downwards, becaufe the Stile in all these
Dials muft point upwards, the North pole
being always elevated, and in so doing, the
Hour-lines, Stile, and Subftile, will ftand
in the Scheme as they are to ftand in the
Dial ; and the manner of the Work will be
the fame as before. Wherefore,

Secondly, Set 32 deg. 11 min. the *Plain's* Re-
clination, from O to *a,* and from C to *b.* A Ru-
ler laid from H to *a,* fhall give you the point B,
through which, and the points H and O, the
Horizon H B O is to be defcribed. And a Ru-
ler laid from H to *b,* fhall give you Z the Ze-
nith point.

Thirdly, Set 60 deg. the *Plain's* Declination
from A to *d,* a Ruler laid from Z the Zenith to
d, fhall cut the Horizon in S the South point
thereof. Thus have you two points Z and S,
through which to draw the Meridian, whofe
Center will be in the Line Q E extended, and
may be found as formerly is taught.

Fourthly,

Fourthly, The Horizon and Meridian being thus drawn, lay a Ruler from E to Z, and it will cut the *Plain* in *e*, and seeing the Pole is 38 deg. 28 min. distant from the Zenith, set 38 deg. 28 min. from *e* to F, and a Ruler laid from E to F, will cut the Meridian in P the Pole of the World, through which point P, and the Center Q, draw the Line P Q for the Axis of the World, and *Substile* of the *Dial.* And again, because the Æquinoctial is 90 deg. from the Pole, set 90 deg. from F, and they will reach just to Æ or *æ* on either side, which are the very points that the *Plain* cuts the Meridian in, and through which points, and the point E, in the Horizon, the *Æquinoctial Circle* must pass; whose Center will always be in the Axis of the World P Q extended.

The *Horizon, Meridian,* and *Æquinoctial,* being thus drawn, you may find the four Requisites in this manner.

1. To find the *Distance of the Meridian from the Horizon* Æ O. The Arch Æ O measured by your Line of Chords, will be found to contain 47 deg. 18 min. which is the *Substile's* Distance from the Meridian.

2. To find the *Height of the Pole or Stile above the Plain* P F. A Ruler laid from *æ* to P, will cut the *Plain* in O, so the Distance F O 42 deg. 52 min. is the Height of the Pole above the *Plain.*

3. The *Distance of the Substile from the Meridian æ* G, which measured upon your Chord, will be found to contain just 90 deg.

4. The *Plain's Difference of Longitude* G P *æ*, or the Arch *æ* G, as before also 90 deg. just.

K   In

In this Scheme two Things are remarkable

1. The *Plain's* cutting the Meridian in its Intersection, with the Æquinoctial. And,
2. The Axis of the World passing through the East point of the *Horizon*, both which denote the *Plain* to be polar Declining, and the *Substile* to be the same with the Hour-line of 6. and the Hour-line of 12 at right Angles thereto, wherefore the Hour-lines may be drawn, as followeth.

To draw the Hour-lines upon the Plain.

First, Lay a Ruler from P to Æ, where the Meridian and Æquinoctial intersect, which is upon the *Plain* at the very point Æ, wherefore there begin to divide the Semicircle Æ G æ, into 12 equal parts at the points ☉ ☉ ☉, *&c.*

Secondly, Lay a Ruler to Q, and every of the points ☉ ☉ ☉, *&c.* and it will cut the Æquinoctial in the Points ✳✳✳, *&c.* dividing that into 12 unequal parts.

Thirdly, A Ruler laid to P, and the several points ✳ ✳ ✳, *&c.* in the Æquinoctial, will cut the *Plain* in the Marks]]], *&c.*

Lastly, A Ruler laid from Q to the several Marks,]]], *&c.* and strait Lines drawn thereby, shall be the true Hour-lines fitting this polar Declining Plain.

For the Stile, it must be a Plate or Wire set upright upon the *Substilar* to an Angle of 42 deg. 52 min. and must point upwards to the North-pole.

The

The Second Variety.

CHAP. XXVI.

How to draw the Hour-lines upon a North Reclining Plain, Declining East or West, the Plain passing through the Meridian, between the Zenith and the Æquinoctial.

IN this (as in the former Examples) three Things most be given, and four found, before the Hour-lines can be drawn.

		deg.	m.
Given	1. The Latitude of the place.	51	32
	2. The Declination of the Plain North W.	60	00
	3. The Plain's Reclination.	16	00

Required
1. The Distance of the Meridian from the Horizon.
2. The Height of the Pole or Stile above the Plain.
3. The Substile's Distance from the Meridian.
4. The Plain's Difference of Longitude.

First, Describe the Circle A H C O for the *Plain*, and cross it with the Diameters A C, and H O, for the Horizontal and Vertical Lines thereof.

K 2 *Se-*

Secondly, (As in the laſt Example) ſet 16 deg.
the *Plain's* Reclination, from
O to *a*, and from C to *b*, a

A North Dial
Declining *Weſt* 60
Reclining ——— 16
Plate 6. Fig. 3.

Ruler laid from H to *a*, ſhall
give the point B, through
which, and the Points H and
O, the Horizontal Circle H
B O is to be deſcribed. Alſo a Ruler laid from
H to *b*, ſhall find the Zenith point of Z.

Thirdly, Set the *Plain's* Declination 60 deg.
from A to *d*, and from H to *e* : So a Ruler laid
from Z to *d*, ſhall cut the Horizon in S the
South, and laid from Z to *e*, ſhall cut it in E the
Eaſt point thereof ; and now having two points
Z and S, through them you may draw the Me-
ridian Circle, as hath been already taught.

Fourthly, Lay a Ruler from E to Z, it will cut
the *Plain* in F, and 38 deg. 28 min. the Com-
plement of the Latitude of the Place, ſet from
F to *f*, and a Ruler laid from E to *f*, will cut the
Meridian in P the Pole of the World, and 90
d. more, being ſet forward from *f* to *m*, and a
Ruler laid from E to *m*, will cut the Meridian
in Æ, the Æquinoctial's Interſection with the
Meridian ; ſo have you two points Æ and E,
through which the *Æquinoctial Circle* muſt paſs,
and a right Line drawn through P the Pole of
the World, and Q the Pole of the Plain, will be
the Axis of the World, and the Subſtilar Line of
the *Dial.*

Theſe three Circles, *viz.* the *Horizon, Meridian,*
and *Æquinoctial,* being deſcribed, the fore-men-
tioned four Requiſites may from thence be eaſily
obtained. For,

1. The *Diſtance of the Meridian from the Horizon,*
is the Arch F H, 64 deg. 29 min.

2. The

2. The *Height of the Pole or Stile above the Plain*
P R. A Ruler laid from *æ* to P, will cut
the *Plain* in *n* : So the Diftance R *n* mea-
fured, will be found to be 30 deg. 59 min.

3. The *Subftile's Diftance from the Meridian,* is the
Arch I M, 64 deg. 26 min.

4. The *Plain's Difference of Longitude* is the An-
gle Æ P Q, which to find. lay a Ruler from
P to Æ ; and it will cut the *Plain* in D, the
Diftance D I meafured upon the Line of
Chords, will give 76 deg. 10 min. for the
Plain's Difference of *Longityde.*

To draw the *Hour-lines upon the Plain.*

Firft, Lay a Ruler upon P the Pole of the
World, and Æ, the Interfeftion of the Meridian
with the Horizon, and it will cut the *Plain* in D,
at which point begin to divide the Semicircle *æ*
I D into 12 equal parts, at the points ☉ ☉ ☉
&c.

Secondly, Lay a Ruler from Q to the feveral
points ☉ ☉ ☉, *&c.* and it will divide the Æ-
quinoftial Circle into 12 unequal Parts in the
points * * *, *&c.*

Thirdly, A Ruler laid from P to every of thefe
unequal Parts * * *, *&c.* will cut the *Plain* in
thefe Marks | | | *&c.* dividing that into 12 other
unequal Parts.

Laftly, If you draw right Lines from Q,
through every of thefe Marks | | | *&c.* they
fhall be the true Hour-lines belonging to your
Plain.

The Stile may be either of Wire or Plate as in
other *Dials,* and muft be elevated above the *Sub-
ftile,* to an Angle of 30 deg. 59 min. and muft
ftand fquare, cr at right Angles to the *Plai..*

The

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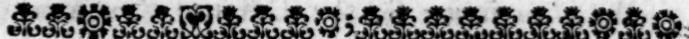
The Third Variety.

CHAP. XXV.

How to draw the Hour-lines upon a North Recli-
ning, *or* Inclining Plain, Declining *East or*
West, which interfects the Meridian between the Æ-
quinoctial and the Horizon.

LET this third and last Example of North
Recliners Declining, be of a North *Plain*,
Reclining 54 deg. and Declining Westward 60
deg. in the Latitude of *London*, 51 deg. 32 min.
This being the third and last Variety of De-
clining Reclining Plains, I shall be somewhat
the larger in the Projection thereof, than I have
been in any of the foregoing; not but that this
Dial is to be made in all respects like (and with
the same Ease) as the former. But herein I shall
shew at large the Manner of Projection, and how
all the Centers are *Geometrically* found; and the
Reasons of their being in such and such Lines,
and at such and such Distances. And also, I
shall project all the *Hour-lines* belonging to the
Plain upon the *Plain* it self by circular Lines, by
which Means the Reader may attain to a more
competent Knowledge in what hath been here-
tofore in this Treatise delivered. For from this
Projection following, all the aforesaid hath
been deduced. And therefore I shall describe
the Manner of the delineating of this Dial, ac-
cording to the following Proposition.

2   Pro-

PROPOSITION.

PLATE VII.

A Circle being described, representing a Declining Reclining Dial-Plain ; how thereon to place the Meridian, Horizon, Æquinoctial, Pole, Zenith, *&c. with all other* Requisites *belonging to such a Dial. And also, to project the* Meridians *of the* Sphere *it self upon the* Plain, *and from thence to draw the* Hour-lines *upon the* Dial-Plain, *according to their true Situation.*

LET the Circle H S O B, represent a *Dial-Plain* in the Latitude of *London* 51 deg. 32 min. Declining from the North towards the West 60 deg. 00 min, and Reclining from the Zenith Northward 54 deg. 30 min.

First, Cross the Circle with the two Diameters H O, and S B; cutting each other at right Angles in the Center Q. And because the *Plain* reclineth 54 deg. 30 min. take 54 deg. 30 min. out of your Line of Chords, and set that Distance upon your *Plain* from S to *a*, from O to *b*, and from B to *c* : Then lay a Ruler from H to *a*, and it will cut the Line S B in Z, so shall the point Z be the Zenith of the Place.

Secondly, Lay a Ruler from H to *b*, it will cut the Line S B in *k*, so shall *k* be a Point in the Line S B, through which the Horizon shall pass: And thus having three Points H *k* O, you may through them describe the Horizon; whose Cen-

ter

ter will be at *m*, the Diſtance *m k* being equal to the Secant of the Complement of the Reclination of the *Plain* ; namely, 36 deg. ——— Or *Geometrically* thus. Draw the right Line *k* O, which divide into two equal parts in *n*, and upon the Point *n*, raiſe a Perpendicular *n m*, extending it till it cut the Line S B in *m*, ſo ſhall *m* be the Centre of the *Horizontal Circle* H *k* O.

Third'y, Lay a Ruler from H to *c*, it will cut the Line S B (being extended) in the Point N, ſo ſhall N be the Nadir point.

Fourthly, Becauſe the *Plain* declines 60 deg. from the North Weſtward ; ſet 60 deg. from B to *d*, and laying a Ruler to Z the Zenith, (which is alſo the Pole of the Horizon) to *d*, it will cut the Horizon in S, through which Point the Meridian muſt paſs.

Fifthly, Take (always) 90 deg. of your Line of Chords, and ſet that Diſtance from *d* to *e*, and laying a Ruler from Z to *e*, it will cut the Horizon in *w* the Weſt point thereof, and a Line drawn from *w*, through Q the Center of your *Plain*, will cut the Horizon (if you extend it as here is done) in E, the Eaſt point thereof, and in ſome part of this Line (extended if Need require) will the Center of the Meridian be ; and where that Point will fall may be thus found.

Sixthly, Divide the Line Z N into two equal parts in F, and upon F erect the Perpendicular F D, cutting the Line Q *w* (extended) in D, ſo ſhall D be the Center of the Meridian of the Place.

Seventhly, If with your Compaſſes you take the Diſtance D P, and with that Extent upon D, as a Center, deſcribe a Circle, you ſhall find that Circle exactly to paſs through the reſpective

Points

Points Z and N, if there be no former Error committed in your Work.

Eightly, Becaufe the Height of the Pole above the Horizon, is equal to the Latitude of the Place, *viz.* at *London* 51 deg. 32 min. fet off 51 deg. 32 min. upon the Meridian from S to P, in this manner.

Ninthly, Lay a Ruler from *w*, the Weft point of the Horizon, (which is alfo the *Pole* of the Meridian) to S, and it will cut the *plain* in *h*, then fet 51 deg. 32 min. from *h* to *f*. A Ruler laid from *w* to *f*, will cut the Meridian in P, fo is P the Pole of the World, diftant from Z the Zenith, 38 deg. 28 min. and a Line drawn through P the Pole of the World, and Q the Center of the *Plain*, will be the Axis of the World; and (extended) will cut the Meridian in M the South Pole.

Tenthly, The Meridian and Horizon being thus drawn, it is eafy to defcribe the *Æquinoc-Bial*, for if you confider the Pofition of that Circle in the Sphere it felf, you know that it always paffes through the Eaft and Weft Points of the Horizon, and cutteth the Meridian at right Angles, it being in all Places 90 deg. diftant from either of the *Poles*. Wherefore, if upon *w*, (the *Pole* of the Meridian) you lay a Ruler to P, the *Pole* of the World, it will cut the *Plain* in *f*, and if you fet 90 deg from *f* to *g*, and lay a Ruler from *w* to *g*, it will cut the Meridian in Æ, fo have you three Points, thro' which the *Æquinoctial* muft pafs, namely, E Æ and *w*, and the Center of the *Æquinoctial* will be the Axis of the World, extended if Need require. To find which, you muft,

Eleventhly,

Eleventhly, Divide the Line *w* E into two equal parts in G, and from the point G, upon the Line E *w,* erect the Perpendicular G K, cutting the Axis of the World in K, so shall K be the Center of the Æquinoctial ; wherefore, if upon K as a Center, with the Distance K *w,* you describe a Circle, that shall be the Æquinoctial, and (if your Work be true) shall pass through the points E Æ and *w* ; then for the dividing of the Æquinoctial.

Twelfthly, Lay a Ruler to P the Pole of the World, (which is also the Pole of the Æquinoctial) to Æ, the Intersection of the Meridian and Æquinoctial, and it will cut the *Plain* in the point 12, at which point you must begin to divide the Circle representing your *Reclining Declining Plain* into 24 equal parts at the points ⊙⊙⊙, *&c.* This done, lay the Ruler to the point P, and every of the 24 equal parts ⊙ ⊙ ⊙, and you shall find it to cut the Æquinoctial Circle in the points, * * * *, *&c.* dividing that Circle into 24 unequal parts, through which unequal parts, and the two Poles of the World P and M, must all the Hour-Circles pass. For the describing whereof you must,

Thirteenthly, Divide the Line P M into two equal parts in the point L, (or, from the point D, the Center of the Meridian, let fall a Perpendicular upon the Axis of the World, which will fall in the same point L) and through the point L, draw an infinite right Line at right Angles to P M, namely, the Line C T, for in that Line will the Centers of all the *Hour-lines* be found, and the manner how to find them is thus (one way) to be effected.

Fourteenthly,

Fourteenthly, Upon the point P as a Center, at the Distance P L, (or to any other Radius of a Line of Chords) describe the Semicircle X L V, and divide it into 12 equal parts at the points ···· &c. beginning your Division at the point J, which is, where the Ruler being laid from P to D (the Center of the Meridian) cuts this last drawn Circle. Then laying a Ruler from P, upon each of these Divisions, you shall find it to cut the Line C T in the points 15, 30, 45, 60, &c. on either side of the point D, and here note, that 15 is the Center of the first Hour's Distance from the Meridian on either side thereof, 30 the Centre of the second, and 45 of the third Hour's Distance from the Meridian, &c.

Fifteenthly, If you place one Foot of your Compasses upon 15, and extend the other to P the Pole of the World, and with that Distance describe a Circle, that Circle shall be the first Hour from the Meridian, and (if your Work be true, shall pass through M the South *Pole,* and also through φ φ, the two first unequal Divisions of the *Æquinoctial Circle,* and so all the rest.

Lastly, If from Q the Center of your *Plain,* and the respective points where the Hour-circles cut the *Plain,* you draw strait Lines, those shall be the true Hour-lines proper for such a *Declination* and *Reclination,* as you formed your Projection for.

Now

Now the Requisites belonging to this, and the like Declining Reclining Plains, are,

			deg.	min.
1. The Height of the Pole above the Plain.		P A	54	43
2. The Distance of the Meridian and Hozon.	Represented by	H Γ	53	31
3. The Distance of the *Substile* from the Meridian.		Γ A	56	41
4. The Angle between the two Meridians.		Æ P R	61	47

All which may be measured upon the Projection, and so their Quantities found. As,

1. To find P A, Law a Ruler from P to *w*, where the *Æquinoctial* and the *Plain* do intersect, and the Ruler will cut the *Plain* on the other side at *x*, so A *x* measured upon the Line of Chords, will be 54 deg. 43 m. the Height of the *Pole* above the *Plain*, (or P Q measured upon a Line of half Tangents, will contain 35 d. 17 m.) the Complement thereof.

2. To find H Γ, the Arch H Γ measured upon the Line of Chords, will give 53 deg. 31 min. the Distance of the Meridian from the Horizon.

3. To find Γ A, the Arch Γ A measured upon the Line of Chords, will give 56 deg. 41 min.

min. the Diſtance of the *Subſtile* from the
Meridian.

4. To find Æ P Q, Lay a Ruler to P the *Pole*
of the World, and Æ the Interſection of the
Meridian and the Æquinoctial, and it will
cut the *Plain* in o, the Arch o B meaſured
upon the Line of Chords, will be found to
contain 61 deg. 47 min. which is the Angle
between the two Meridians.

Thus have you in this Scheme delivered the
true and genuine way of delineating Sun-Dials,
deduced from the Sphere it ſelf, by which the
Reaſon of all that hath been before delivered, is
rendred obvious, and ſufficiently demonſtrative
for this place. But here you ſee, that the Cen-
ters of the Meridians or Hour-circles fall out
to be very remote, and that there will be requi-
red a large Tangent-line for their Deſcription,
which will (for the moſt part) run out very far,
and ſometimes, almoſt to an infinite Excurſion.
I therefore choſe rather to ſhew, how the Hour-
lines might be drawn, without having any Regard
to this Tangent-line, or without projecting of
the Hour-lines upon the *Circular Plain*, and there-
fore the ways before delivered are far more apt
for Practice than this, though this be more ſa-
tisfactory to the inquiſitive Reader, who will
not be ſatisfied only with the doing, but of the
underſtanding as well of what he does, and it *is*
for the Satisfaction of ſuch, that I have here ad-
ded this Propoſition.
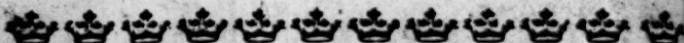
L CHAP. XXVII.

C H A P. XXVII.

Concerning Inclining Plains, both Direct and De-clining.

OF *Reclining* Plains there are but two forts, as hath been before inftanced, and thofe are either *Direct* or *Declining*. The *Direct* are thofe *Reclining Plains* which do directly behold the *Eaft*, *Weft*, *North*, or *South* Points of the Horizon. And the *Decliners* are thofe which (befides their Reclination from the Zenith) do refpect two of the fore-mentioned Cardinal Points, as,

(1.) The *South* and the *Weft*.
(2.) The *North* and the *Weft*.
(3.) The *South* and the *Eaft*.
Or, (4.) The *North* and the Eaft.

The $\begin{cases}\text{Firft}\\\text{Second}\\\text{Third}\\\text{Fourth}\end{cases}$ fort are called $\begin{cases}\text{South}\\\text{North}\\\text{South}\\\text{North}\end{cases}$ declining Weft. declining Eaft. $\Big\}$ Reclining

I alfo before intimated, and gave Examples, that of Direct Recliners, there were three forts, *viz.*

1. Such as Reclining from the Zenith, do behold either the due *Eaft*, or due *Weft* points of the Horizon ; and of this fort there is only one kind, and no Variety in any Cafe.———

2. *South Recliners*, of which there are three Varieties.———

And 3. *North Recliners*, of which alfo there are three Varieties.———

Again,

Plate II.

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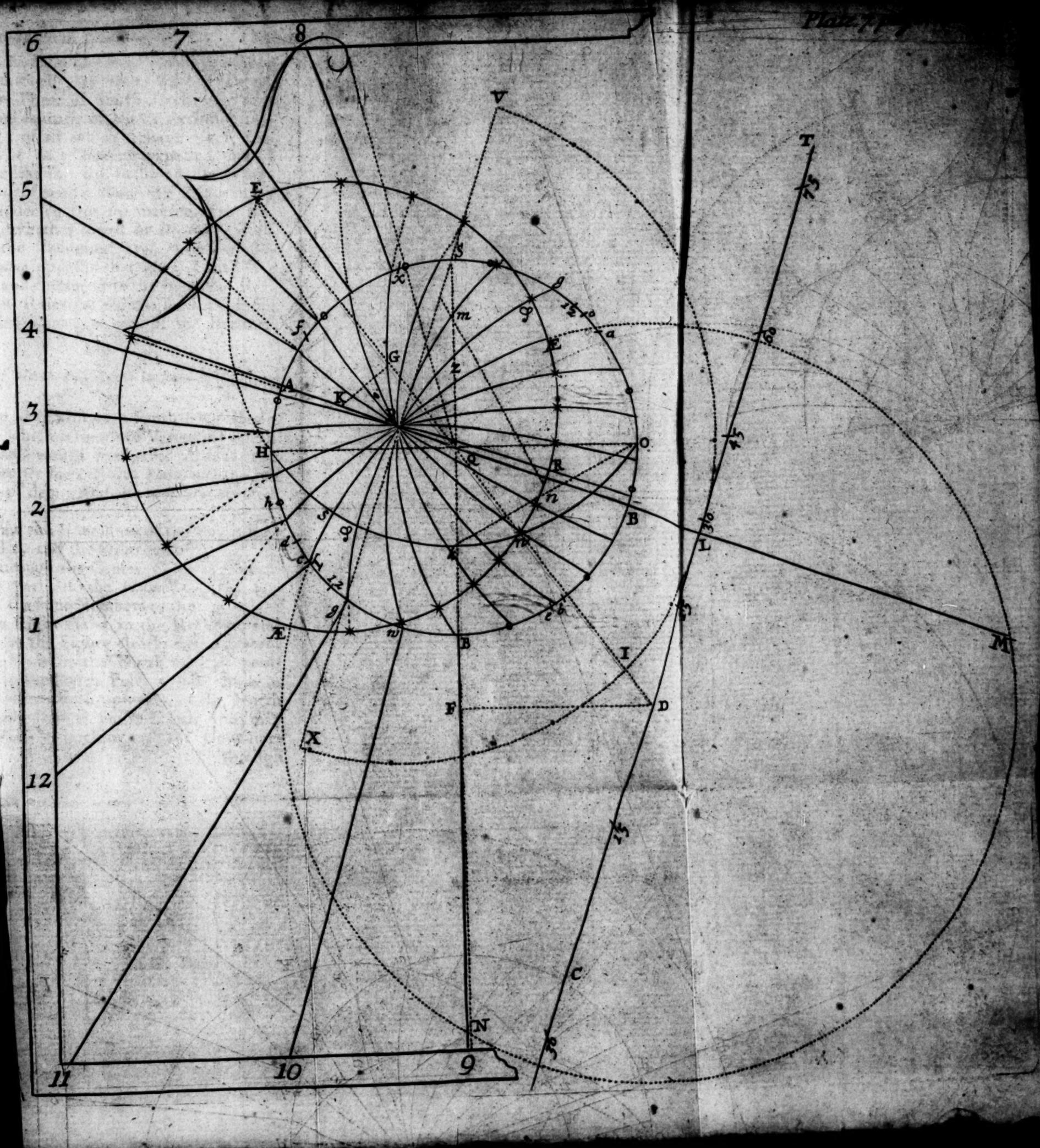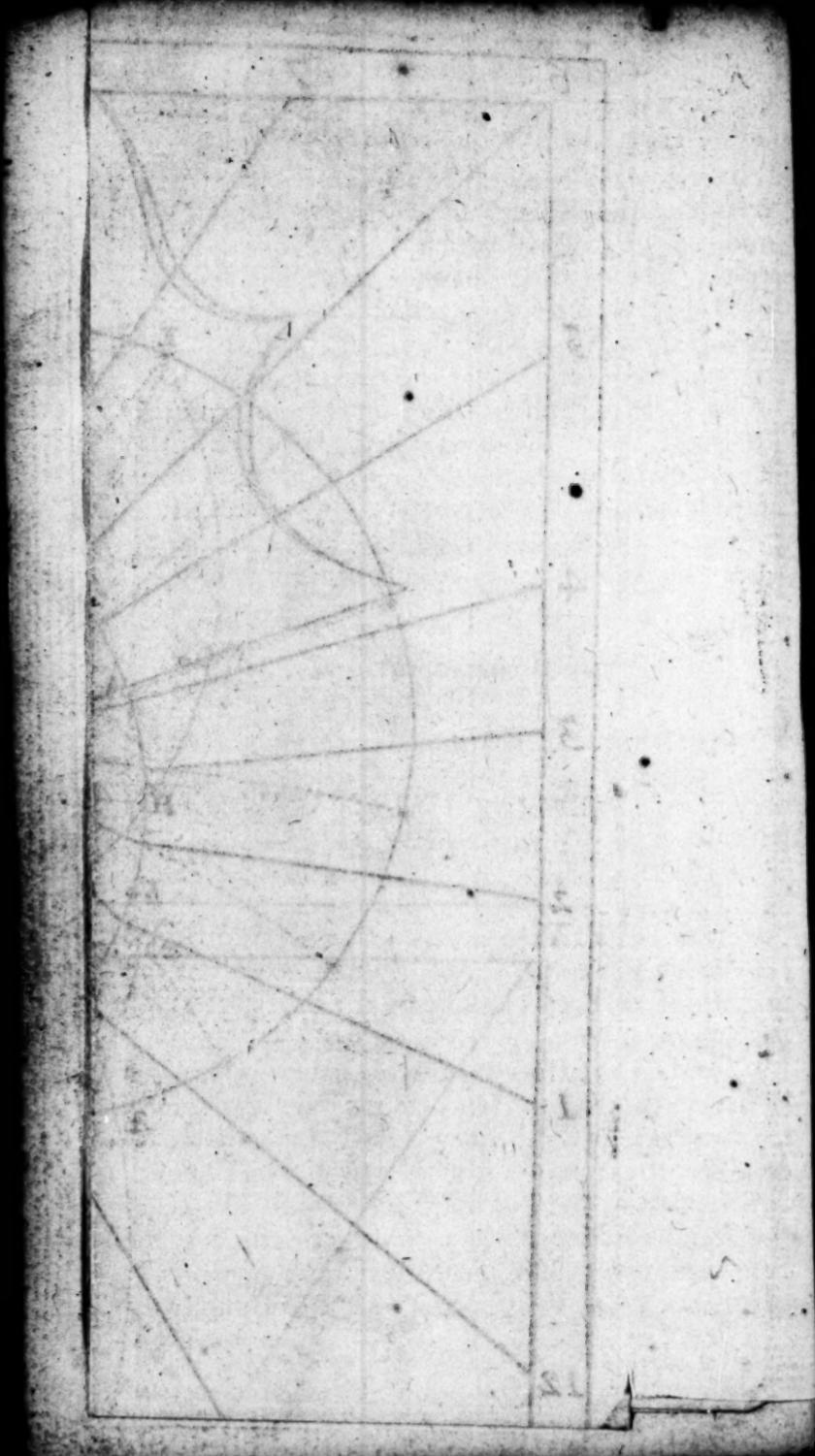
Again, Of *Reclining Declining*, I told you there were six Varieties also, as there were of Direct Recliners, *viz.* Three of South Declining *Plains* Reclining, and as many of North Reclining Declining *Plains* ; of all which I have given Examples, and it may be now expected that I should do the like for the Inclining Plains opposite to them, of which there are also as many Varieties, but seeing that the making of the Reclining *Dial*, whether *Direct* or *Declining*, doth also make the Inclining *Dial*, whether *Direct* or *Declining* opposite thereunto, I shall save the Labour, and commend to the Ingenious Reader some few Rules by which he shall easily frame the Inclining *Dial* out of the Recliner, And,

I. Of North and South Incliners.

I will take for Example a South *Plain* Reclining 55 deg. which is the third Variety of South Recliners, and I would from that deduce the Hour-lines proper for a North *Plain* inclining as much, *viz.* 55 deg. And it is easily effected. For,

If you draw the Hour-lines of the South Recliners 6 A B 6, and the Stile thereof also, quite through the Center Q, to   *Plate* 6. the opposite part of the *Plain*, 6 C   *Fig.* 4. D 6, and set the same Numbers to the Hours on the Right Hand in the Recliner, and the contrary, as the Figure clearly demonstrates: And let the Axis in the North Incliner point downwards to the South Pole, as the Axis in the South Recliner doth upwards to the North Pole, and your Dial is finished. Or you may effect this Work by pricking off the Hour-lines

L 2   through

through the Paper, and turning it upside down, and that will effect the same thing, only changing the Names of the Hours. Or, again, if you turn the South Reclining *Plain*, 6 A B 6 about, upon the Center Q; till the Line A B come to be in the Place of C D, then will the Hours, Stile and all, be truly named and posited ; and the very South Recliner will become the North Incliner without any Alteration.

II. *Of East and West Incliners.*

There is little Difference in drawing of the *East* or *West* Inclining *Dials* from the Reclining *Dials* opposite to them, from drawing the North Incliner before from the South Recliner. For,

In the Example of the *East* and *West* Reclining and Inclining *Dial* before going, Chapter 10. The *Dial* as it there stands, represents an *East* or *West* Reclining *Plain*. But if you turn the *Dial* about upon the Center Q, till the Letter N come to be in the place of the Letter S, in that Figure, then will the same Dial represent both an *East* and *West Dial* Inclining 35 deg. as now it doth an *East* or *West* Reclining as much. The Substile, Stile, Meridian, and the rest of the Hour-lines retaining the same Names or Denominations, as now they do.

III. *Of North or South Declining Inclining Plains.*

Of North and South Reclining Declining *Plains*, there were six Varieties, Examples of each have been largely given. There are as many of North and South Incliners, but seeing
they

Plate 6. p.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.
South Reclining

North Inclining

Fig. 5.

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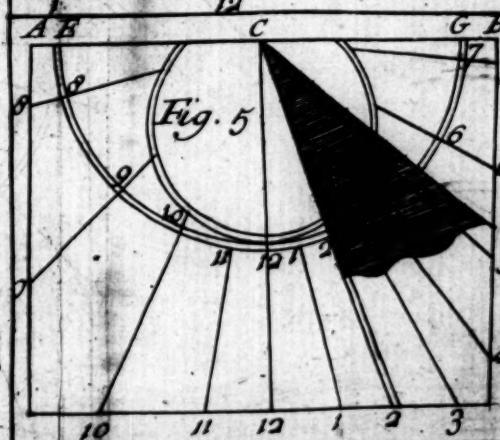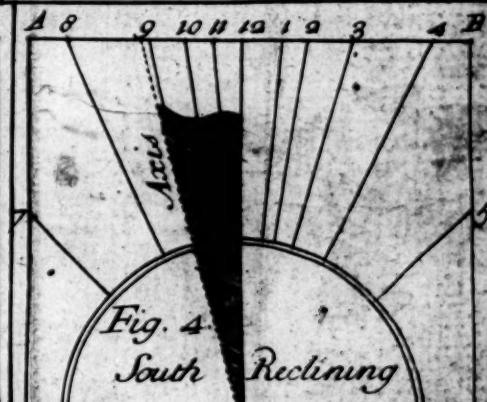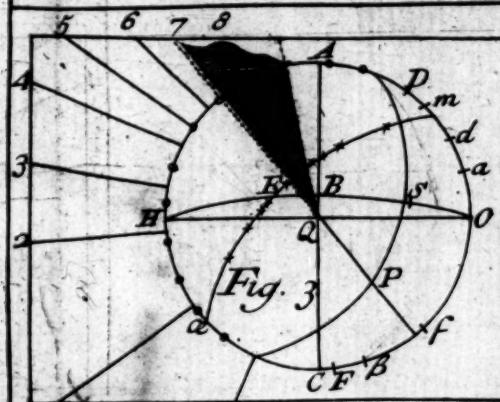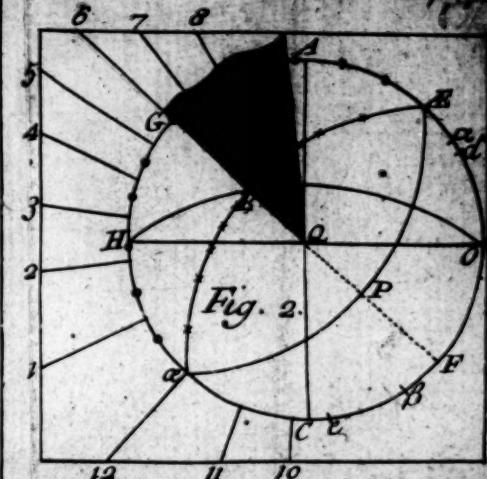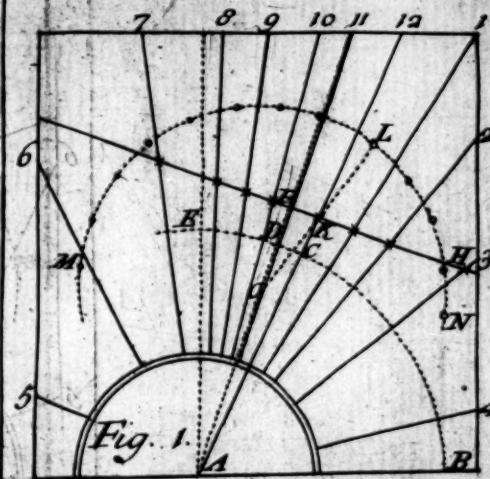
they may be so easily deduced out of their oppo-
site Recliners, I shall forbear giving Examples,
and the Way is not much differing from the
Rules before given for Direct Reclining and In-
clining *Plains.* For seeing the Reclination is alike
proper to each, and the Deflection of the Sub-
stile from the Meridian in the Declinations do
so directly agree, they may both be reduced to
one and the same *Dial,* as the other were.

Thus, If any Reclining *Dial* be so inverted,
that the upper part thereof become the nether,
and after this Inversion the right side of the Re-
cliner become the left side of the Incliner, and
the contrary, the Inclining *Dial* having the same
Declination, shall be framed out of the Recli-
ner, and the contrary. Only the Denominations
of the Hours must be changed. For the Fore-
noon Hours in the Recliner, will be the After-
noon Hours in the Incliner, and the Afternoon
Hours of the upper Dial, the Forenoon Hours of
the nether.

CHAP. XXVIII.

A General Rule to know which Pole, *whether the*
North *or the* South *is to be elevated over any*
Plain.

THE Stile of every Dial respecteth (or ra-
ther lieth parallel with) the Axis of the
World, and always pointeth upwards or Down-
wards, to one of the Poles. Now when you
have drawn your Dial (though truly) you may
be to seek, whether it be the North or the South

Pole

Pole that must be elevated ; wherefore to avoid any Mistake, and to inform you which Pole is to be elevated, Observe this General Rule.

Upon all upright Plains, whether direct or declining, upon the {South} {North} side the {South} {North} Pole.

Upon all {Recliners?} {East and West Incliners} the {North} {South} Pole.

Upon all {North Recliners?} {South Incliners} whether {Direct or Declining} {North} {South} Pole.

Upon all {South Recliners whether direct or declining.} {North Incliners} If the Plain pass between the {Zenith and the Pole,} {Nadir the} {Horizon} {South} {North} {South} Pole.

This Rule being duly observed, there will be no Difficulty to find which is elevated.

A Second

A
Second Way
OF
DIALLING,
Geometrically Performed.

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PART II.

✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠

IN the foregoing First Part, you have a most absolute and perfect Way of delineating *Sun-Dials* upon all forts of *Plain Superficies* in what Position foever fituate, and in any Latitude, whether the *Plains* be direct, or do decline, or whether they both decline and recline : And alfo you may there find, not only the manner how to

to make *Dials*, but to know the Grounds and Reaſon of *Dials*, deduced from the Sphere or Globe projected *in plano*, upon the *Dial-Plain's* Superficies.

But notwithſtanding the Exactneſs and Rationality of delineating of *Hour-lines* upon all *Plains*, and in all Places, as is before taught; yet the Ways there delivered, may (in ſome Caſes, at ſome times) be found inconvenient to put in Practice : As (1) When the Centers of ſome of the *Circles* fall out to be very remote. (2) When the unequal Diviſions of the *Æquinoctial Circle* come very near or cloſe together, which they will always do, when the *Pole* hath but ſmall Elevation above the *Plain*, and ſuch like. For the Removal of which Inconveniencies, I ſhall in this Second Part add another *Geometrical Way of Dialling*, which ſhall be both plain, eaſie, exact, and quick of Diſpatch; and all of it performed by ſtrait Lines, and not by Circular Lines, as the former Way requires. And moreover, this ſecond Way hath a Convenience, whereas moſt other *Geometrical Ways of Dialling* are liable to out-run the Limits of the *Plain*, by almoſt infinite Excurſions : For in this Way, having firſt made a preparative Scheme upon Paper (or Paſt-board rather) you ſhall have but very few Lines to draw upon the *Dial-Plain* but the Hour-lines themſelves.

In this Second Way, I ſhall be brief, beginning firſt to ſhew how to deſcribe the Hour-lines upon *Upright Declining Plains*; referring the Delineation of Hours upon the *Horizontal full North, South, Eaſt*, and *Weſt Plains* (whether upright or reclining) till afterwards : And the Reaſon for my ſo doing, will of it ſelf appear, when I ſhall come to treat of them. Wherefore to proceed.

Sect. I.

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SECTION I.

How to draw Hour-Lines upon an Upright South Plain Declining from the South towards the West 20 deg. in the Latitude of London, 51 deg. 32 min.

HAving the Latitude of the Place, and the Declination of your *Plain* given, before you come to draw the Hour-lines upon the *Plain*, you must first draw your preparative Scheme as followeth.

I. *How to draw a* **Preparative Scheme** *suitable to any Declination in any Latitude.* Plate 8, *Fig.* 1.

First, With 60 deg. or the Radius of your Scale of Chords, describe the Quadrant of a Circle A B D, extending the side B A to C, so that A C be equal to A B : And then draw the Right Line D C.

Secondly, On the point B, erect the Perpendicular B *m*.

Thirdly, Take 51 deg. 32 min. (the Latitude) out of your Line of Chords, and set them from B to F, and from D to G, and laying a Ruler from A, to F and G, draw the two Lines F K, and G I.

Fourthly, From the point G, draw the Line G H, parallel to D A, or perpendicular to B A.

Fifthly, Take 20 deg. (the *Plain's* Declination) out of your Scale of Chords, and set them from
D to E,

D to E, and through the point E, draw the Line E L, parallel to D A.

Sixthly, With 60 deg. (or the Radius of your Scale of Chords) taken in your Compasses, set one Foot in the point D, and with the other describe the Arch A O, which divide into three equal parts in the points P and Q, for the whole Hours, each of which three Hour-spaces A P, P Q, and Q O, divide into four equal parts at * * *, * * *, * * *, for Halfs and Quarters of Hours. Which done, if you lay a Ruler to the point D, and the points P and Q, the Ruler will cut the Line A C in the points 2 10, and 1 11, and by these points the Line A C is divided into three unequal parts in the points 3, 9, 2, 10, 1, 11 and 12, representing four Hours. And if from D, you lay a Ruler over the several Spaces in the Hour-line A C into four unequal parts for Halfs and Quarters of Hours. And thus is your preparative Scheme so far finished. Wherefore now let us proceed,

I I. *To draw the Meridian,* Stile, Substile, *and Hour-lines upon the Plain it self.* Plate 8, *Fig.* 2.

First, Upon your *Dial-plain* draw a right Line as S T, for the Meridian, and Hour-line of 12. Upon which, assign any convenient point, as R, for the Center of your Dial; through which point R, draw the Line R W perpendicular to S T.

Secondly, Out of your preparative Scheme take the Line B K, and set it upon your *Dial-plain*, from R to T; also, from the preparative Scheme take B I, and set it on your *Dial-plain* from R to W, on the right Hand, because the *Plain* declineth

neth Weſt, and from T to V, make the Rectangled *Parallelogram* R W V T on the Eaſt ſide.

Thirdly, Out of the preparative Scheme take
the Line L A, and ſet it upon the *Dial-plain* from
T to X, and from W to ⊖, and draw the Lines
R X for the Subſtilar Line, and R ⊖ for the
Hour line of Six, which draw quite through
the Center R.

Fourthly, Out of your preparative Scheme,
take the Line E L, and ſet it upon your *Dial-
plain* from R to 12, and from X to Y, perpendicular to R X, and draw the Line R Y for the
Axis (or Stile) of your Dial.

Fifthly, Out of your preparative Scheme, take
the Line G H, and ſet it on your Dial-plain
from R to Z, and draw the Line Z 6, parallel
to W V, till it cut the Hour-line of Six in 6.

Sixthly, Make R 6 above the Center, equal
to R 6 below the Center, and draw the two Lines
12 6, and 12 6.

Seventhly, Out of your *Dial-plain* take the
Length of the Lines 12 6, and 12 6, and ſet
them upon the preparative Scheme from
B to *b*, and from B to *a*. And laying a Ruler
from C to *a* and *b*, draw the Lines M C, and
N C.

Laſtly, From the point A or 3, 9, take the
neareſt Diſtance to the Line N C, and ſet that
Diſtance upon your *Dial-plain* from 12 to 9, for
it will (if you work truly) divide the Line 6,
12 into two equal parts in 9. Alſo ſet one Foot
of the Compaſſes in the point 2, 10 in the Line
A C of the preparative Scheme, with the other
take the neareſt Diſtance to the Line N C, and
ſet that Diſtance upon your Dial-plain, from 12
to 8, and from 6 to 10.—— Again, ſetting one
Foot of the Compaſſes in the point 1, 11. in the
Line

Line A C of the preparative Scheme, with the other take the nearest Distance to the Line N C, and set that Distance from 12 to 11, and from 6 to 7. So is the longer Line 6, 12 on your Dial-plain, divided into 6 unequal parts in the points 7, 8, 9, 10, and 11; through which points, Lines drawn from the Center R, shall be the true Forenoon Hours.

For the Afternoon Hours, the shorter Line 12, 6. on your Dial-plain, must be divided from the Line M C in the preparative Scheme, as the longer Line 12, 6 was before divided; by taking the least Distance from A or 9, 3 to the Line M C, and setting it from 12 to 3, or from 6 to 3.——— Also the least Distance from 2, 10, to M C, in the preparative Scheme, will reach from 12 to 2, and from 6 to 4.——— Likewise the least Distance taken from from 1, 11, to the Line M C, in the preparative Scheme, will reach from 12 to 1, and from 6 to 5. So is the shorter Line 12 6, on the Dial-plain, divided into 6 unequal parts in the points 1, 2: 3, 4, 5. Through which Points, and the Center R, right Lines being drawn, they shall be the true Hour-lines upon the Plain. And so is your Dial finished.

If you would incert the Halfs and the Quarters of Hours into your Plain, you may easily do it, if from the preparative Scheme you take the nearest Distance from the Half and Quarter Points in the Line A C, and transfer them to the Lines 12, 6, and 12, 6, in the Dial-plate.

Sect.

✿✿✿:✿✿✿✿✿✿✿✿✿✿✿✿:✿✿✿✿

SECTION. II.

How to defcribe the Hour-lines upon the Horizontal,
Full South, North, Eaft, and Weft, Erect or Recli-
ning Plains. Plate 8. Fig. 3.

IN thefe kind of Plains, which directly behold
the Four Cardinal *North, South, Eaft* and
Weft points, the Latitude of the Place, and Re-
clination of the *Plain* being known, there is no-
thing required, but to know the Elevation, or
Height of the Pole above the *Plain*, which how
to find, is fufficiently taught in the Fourth and
Fifth Sections of the Third Part of this Book :
And therefore I fhall not here mention the fame
again, but refer you to thofe fore-mentioned
Fourth and Fifth Sections of the Third part
hereof. Wherefore, to draw Hours upon any of
thefe *Erect, Direct,* or *Direct Reclining Plains,* when
the Height of the *Pole* or *Stile* above the *Plain* is
found, you have no more to do ; but,

Firft, Draw a right Line A B for the Hour-
line of Six, and another at right Angles thereto,
for the Hour-line of 12, as the Line ⊙ X.

Secondly, With the Radius of your Line of
Chords 60 deg. upon ⊙ as a Center, defcribe
the Semicircle A X B. And the Height of the
Pole above the Plain being known, (as for an
Horizontal Dial for *London,* where the Pole is
elevated 51 deg. 32 min.) Take 51 deg. 32
min. from your Chord, and fet them upon the
Semicircle from X to F, and from X to I, and
through the Points F and I, draw the Lines 6 F
M and I.

and 6 I, parallel to ☉ X, and draw the Lines
X 6 and X 6 on either fide of the Meridian.

Thirdly, (Having Recourfe to your former pre-
parative Scheme) take in your Compaffes the
Length of the Line X 6, and fet it upon the
preparative Scheme from B to *c*, and laying a
Ruler from A to *c*, draw the pricked Line C △.

Fourthly, In the preparative Scheme from the
point A or 9, 3, take the neareft Diftance to the
Line △ C, and fet it upon the Lines X 6, and X
6, from X to 3, and from X to 9. Alfo from
the point 2, 10, in the Line A C of the prepara-
tive Scheme, take the neareft Diftance to the
Line △ C, and that Diftance fet upon the Lines
X 6, and X 6, from X to 10 and 2, and from
6 to 8, and from 6 to 4.—— Likewife, take the
neareft Diftance from the point 1, 11, in the
Line A C of the preparative Scheme, to the Line
△ C, which Diftance will reach from X to 11,
and from X to 1, and alfo from 6 to 5, and from
6 to 7. So are the two Lines X 6 and X 6 di-
vided each of them into fix unequal parts, the
one in the points 1, 2, 3 4, and 5, and the
other in the points 11, 10, 9, 8, and 7. Thro'
which points, right Lines drawn from the Cen-
ter ☉, they fhall be the true Hour-lines proper
for an Horizontal Dial, for the Latitude of *Lon-
don,* 51 deg. 32 min.

For the Stile of this Dial, a Line drawn from
the Center ☉, through either of the Points
F and I, fhall reprefent the Axis of the
World, or Stile of the Dial.

*For a Vertical or Erect South Dial for the same La-
titude 51 deg. 32 min.*

The Height of the Pole above a South Plain
in the Latitude of 51 deg. 32 min. is 38 deg. 28
min. the Complement of the Latitude. Where-
fore,

First, Take 38 deg. 28 min. from your Scale
of Chords, and set them from X to G, and
from X to H, and draw the Lines G M and H L,
parallel to ☉ X. Draw also X M and X L.

Secondly, Take the Length of the Line X M
and X L, and apply it to your preparative
Scheme, setting it from B to *d*, and laying a
Ruler from C to *d*, draw another pricked Line
C Æ.

Thirdly, The nearest Distances taken from the
Points A 2, 10, and 1, 11, in the Line A C of the
preparative Scheme, will (being transferred from
thence to the *Dial-plain*) divide the Lines X M
and X L, each of them into six unequal parts,
through which Divisions, and the Center ☉,
Lines being drawn, they shall be the true Hour-
lines of an *Erect South Dial* in the Latitude of
London.

A Line drawn from ☉ (the Center of the Dial)
through the Points H or G, shall represent
the Axis of the World, and be the Stile of
this Dial.

For a Direct North Reclining Plain.

Let your Example be of a *Direct North Plain,*
Reclining from the Zenith 25 deg. and such a *Dial*
is described in the 17th Chapter of the First Part,

and

and the Height of the Pole or Stile above the Plain, was there found to be 63 deg. 28 min. And so it will be found to be by the Rule delivered in the Fifth Section of the Third Part of this Book.

First, The Height of the Stile being found to be 63 deg. 28 min. take 63 deg. 28 min. from the Scale of Chords, and set them from X to E, and from X to K, and draw the Lines E C and K D, parallel to the Meridian ⊙ X. Also draw the Lines X C, and X D.

Secondly, Take the Length of the Line X C or X D, and set it upon the preparative Scheme from B to *e*, and draw a third pricked Line as *e* C.

Thirdly, The nearest Distances taken from the Points A 2, 10, and 1, 11, in the Line A C, shall, (being set upon the Lines X C and X D) divide them each into six unequal parts, through which and the Center ⊙, right Lines being drawn, they shall be the true Hour-lines of a North Direct Plain Reclining 25 deg. in the Latitude of *London*.

The Stile must be drawn from the Center ⊙, through the Point E or K.

For Direct East or West Plains, whether Erect or Reclining.

For *Erect Direct Plains*, where the Hour-lines are parallel one to another, the Stile or Pole having no Elevation, the best Way to make them, is, as is directed in the Sixth Chapter of the First Part. And therefore in this Place, nothing more need be said concerning them. But,

For

For *Eaſt* and *Weſt Recliners.*

The beſt Way to deal with theſe kind of *Plains*, is to refer them to a new Latitude, and to a new Declination in that new Latitude, both which are eaſily attained by this following *GE-NERAL RULE.*

1. *The new Latitude, is always the Complement of the Old Latitude.*
2. *The new Declination in that new Latitude is the Complement of the Reclination.*

So that if a direct Eaſt Plain, in the Latitude of *London* 51 deg. 32 min. ſhould recline 40 d. and you would find the new Latitude, and new Declination;

Firſt, The Complement of the old Latitude 51 deg. 32 min. is 38 deg. 28 min. And that muſt be the new Latitude.

Secondly, The Reclination being 40 deg. The Complement thereof is 50 deg. And that is the New Declination.

So that if (by the Directions of the firſt Section hereof) you make an Erect Dial to decline 50 deg. in the Latitude of 38 deg. 28 min. that Dial ſhall ſerve for an *Eaſt* or *Weſt Dial*, Reclining 40 d. in the Latitude of 51 d. 32 min.

Thirdly, Although this Declining Plain be truly made, yet the placing of it upon the *Dial-Plain* differeth from *Erect Plains*: For, in all Erect Declining Plains, the Hour-line of 12 is always perpendicular to the Horizontal Line of the Plain. So in all *Eaſt* and *Weſt* Reclining Plains, the Hour-line of 12 muſt lie parallel to the Ho-

M 3   rizontal

rizontal Line of the Plain. As you may fee in the *Figure* Chap. 10, of Part the Firſt.

It may here be expected, that I ſhould ſay ſomething concerning *Declining Reclining Plains*, which this Geometrical Way will very well perform by referring them to a new Latitude, and a new Declination, where they will become *Erect Declining Plains*; but there are three Ways in this Book already taught, how to effect the ſame by other Means. I thought good to omit them in this Place; and to give Examples in Erect Direct, in Direct Reclining, and in Erect Declining Plains (as being of all others the moſt uſeful.) And ſo I ſhall conclude this *Second Geometrical Way of Dialling.*

The Preparative
Scheme.

Fig. 1.

Fig. 2.

South declining West
20 deg:

Fig. 3.
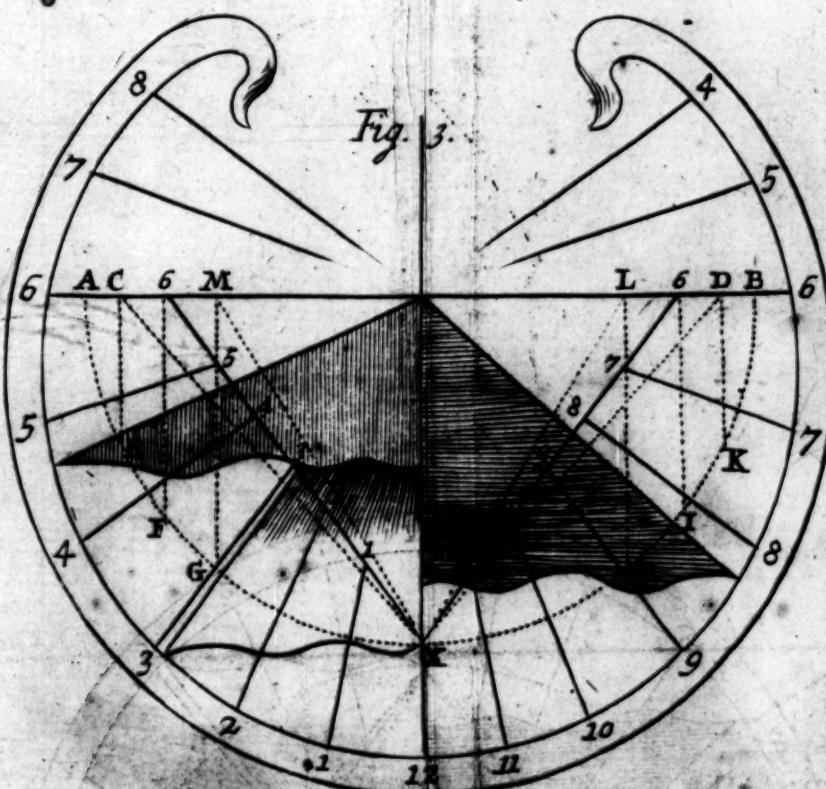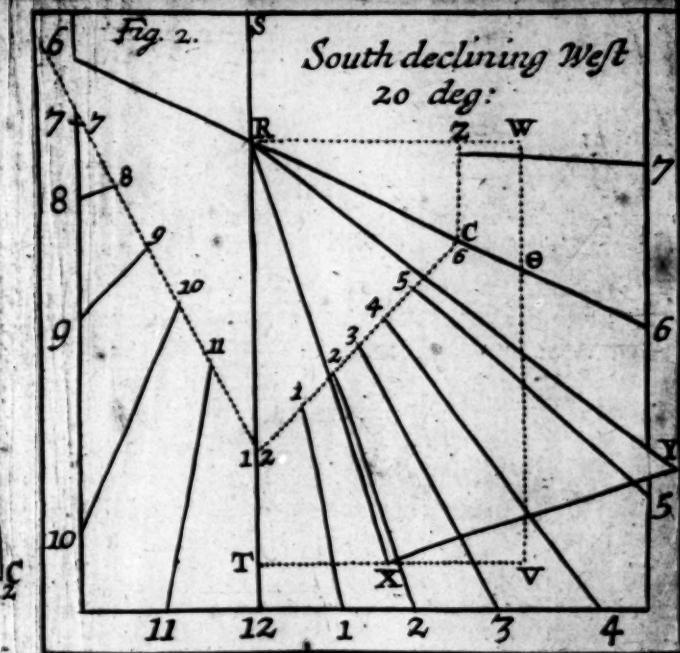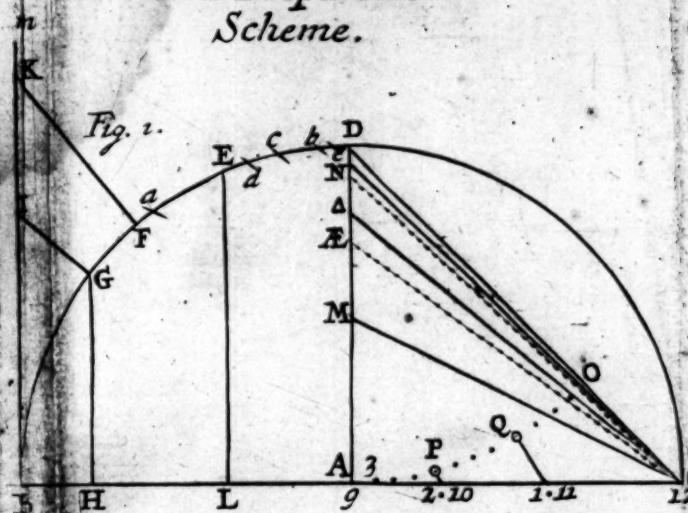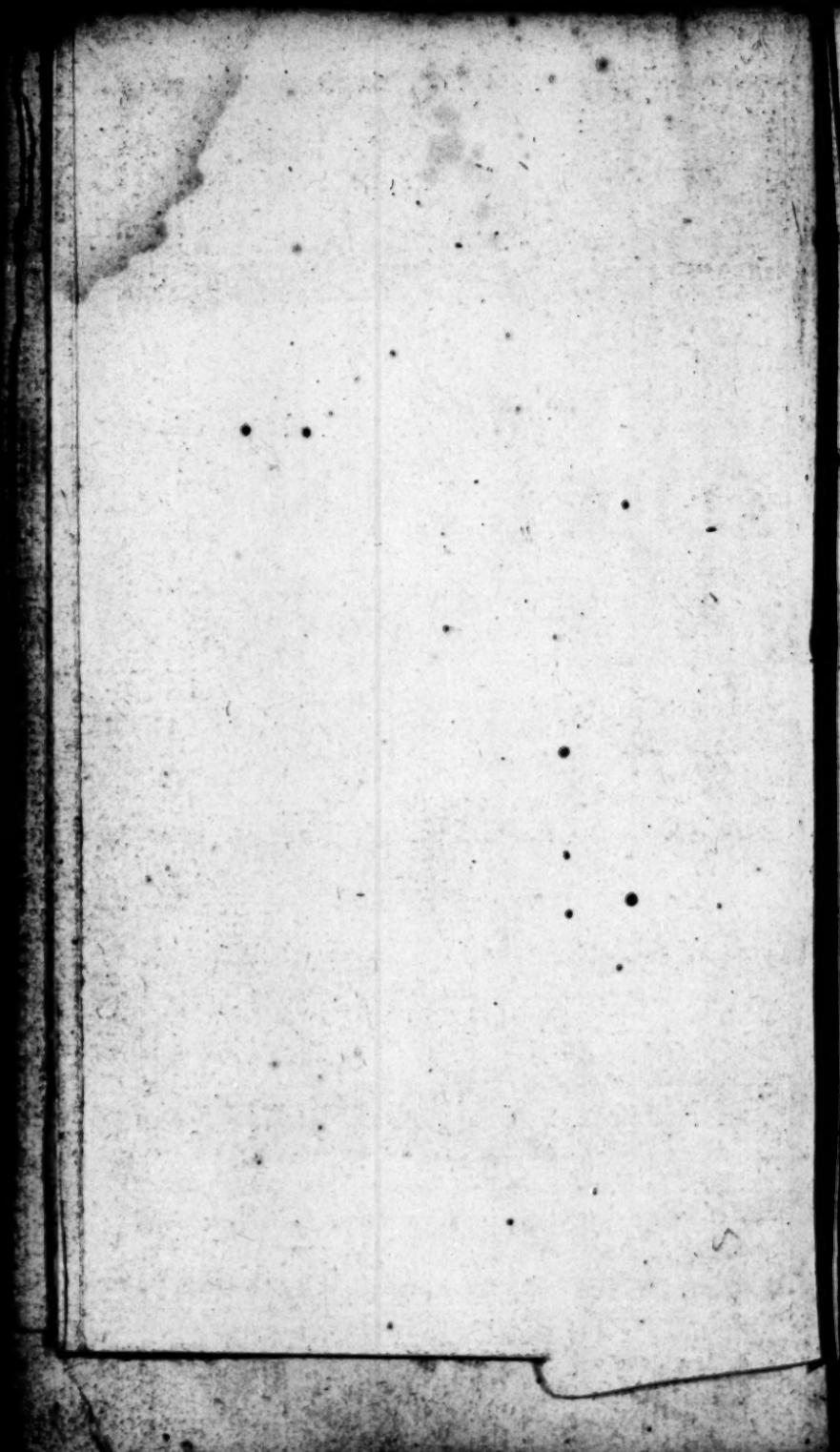
The ART of
DIALLING,

Arithmetically Performed.

By the *CANONS* (or *TABLES*) of
Artificial *Sines* and *Tangents*.

✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠

PART III.

✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠✠

The Argument.

WHEREAS the two foregoing *Geo-metrical* Ways, of delineating or ma-
king of *Sun-Dials*, may be rejected by
some, and a more accurate Perfor-
mance of the same required by others,
I thought good, (to make this Treatise the more
complete, which for a *Geometrical* Way is already
perfect

perfect enough) to add the Canons, Analogies, or Proportions, by which the several Requisites in all *Plains* may be *Arithmetically* attained, by the Help of the Canons or Tables of Artificial Sines and Tangents (than by which there can be no exacter way.) Which Tables are already in most Men's Hands, and the general Use of them no less common: Wherefore I shall say nothing of that in this Place, but proceed to the finding the 'forementioned Requisites, as followeth. And,
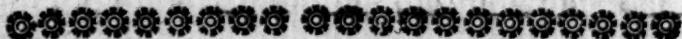
SECTION I.

Of Vertical or Horizontal Plains.

IN these *Plains* there is Nothing required but the Height of the *Pole* above the *Plain*, which in all Places is equal to the Latitude of the Place, for which the Dial is to be made.

SECTION II.

Of North and South Erect Direct Plains.

IN these *Plains* also there is Nothing required but the Height of the *Pole* above the *Plain*, which in all places is equal to the Complement of the Latitude of the Place. Wherefore, Subtract the Latitude of the Place, for which your Dial is to be made from 90 deg. and the

Remainder

Remainder is the Height of the Pole above the
South or North Erect Direct *Plain.*

<pre>
                              deg. min.
From————————————————90   00
Subſtract Latitude——51   32
                              ————————
There remains ————38   28
</pre>

Which is the Height of the *Pole* above a Di-
rect North or South *Plain* in the Latitude of 51
deg. 32 min.

SECTION III.

Of North and South Erect Declining Plains.

BUT in Erect Declining *plains,* (beſides the
Latitude of the Place, and the Declination
of the *Plain*) there are three Things requiſite to
be found, before you draw the Dial, and they
are,

1. *The Height of the Stile (or Pole) above the
Plain.*
2. *The Diſtance of the Subſtile from the Meridian,*
3. *The Plain's Difference of Longitude.*

Example, In the declining *Plain* in *Chapter* 8.
whoſe Declination was 24 deg. 20 min. in the
Latitude of 51 deg. 32 min.

<div align="right">1. For</div>

1. *For the Height of the Pole above the Plain.*

As the Radius 90 deg.   10.000000

Is to the Co-fine of the Latitude ⎱
38 deg. 28 min.   ⎰   9.793831

So is the Co-fine of the Declina- ⎱
tion 65 d. 40. m.   ⎰   9.959596

To the Sine of 34 deg. 33 min.   19.753427

Which 34 deg. 33 min, is the Height of the
Pole above the *Plain.*

2. *For the Diftance of the Subftile from the Meridian.*

As the Sine of 90   10.000000

Is to the Sine of the *plain's* De- ⎱
clination 24 d. 20 m.   ⎰   9.616059

So is the Co-Tangent of the Lati- ⎱
tude 38 d. 28 m.   ⎰   9.900086

To the Tangent of 18 d. 10. m.   19.516145

Which 18 deg. 10 min. is the Diftance of the
Subftile from the Meridian.

3. *For the Plain's Difference of Longitude.*

As the Co-fine of the Latitude 38 d. ⎱
28 min.   ⎰   !9.793831

Is to the Radius 90 deg.   10.000000

So is the Sine of the Diftance of ⎱
the Subftile from the Meridian   ⎰ 19.493851
18 deg. 10 min.   ⎰

To the Sine of 30 deg. 00 min.   9.700020

Which 30 deg. 04 min. is the *Plain's* Diffe-
rence of Longitude.
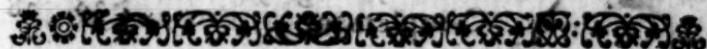
Sect.

SECTION IV.

Of South Direct Reclining Plains.

IN thefe *Plains,* (the Latitude of the Place, and the Reclination of the Plain being given) there is only required the Height of the *Pole* above the *Plain:* In which there are three Cafes, in all which you may find the Stile's Height, as followeth:

1. If the Reclination of the *Plain* be lefs than the Complement of the Latitude of the Place, fubftract the Reclination out of the Complement of the Latitude, and the Remainder will be the Height of the *Pole* or *Stile* above the Reclining *Plain.* But,

2. If the Reclination of the *Plain* be more than the Complement of the Latitude, fubftract the Complement of the Latitude from the Reclination, and the Remamder fhall be the Elevation of the *Pole* above the *Plain.*

3. If the Reclination be equal to the Complement of the Latitude, the *Pole* hath no Elevation over fuch a *Plain,* but is an Æ-*quinoctial Plain,* and muft be made by the Rules delivered in the Twelfth Chapter of the firft Part of this Book.

1. Cafe

deg. min.

1. Cafe
{
Latitude 51 deg. 32 min. } 38 28
Complement
Reclination	22 10
_____
Height of the *Pole* above } 16 18
the *Plain*.
}

2. Cafe
{
Reclination	62 23
Latitude 51 deg. 32 min. } 38 28
Complement
Height of the *Pole* above } 23 55
the *Plain*.
}

SECTION V.

Of North Direct Reclining Plains.

IN thefe *Plains* alfo (the Latitude and Recli-
nation being given) there is only required
The Height of the *Pole* above the *Plain*.

To find this,

1. Add the Complement of the Latitude to
the Reclination, and the Sum of them is the
Height of the *Pole* above the *Reclining plain*,

deg. min.

Lat. 51 deg. 32 min. Compl.	38 28
Reclination	27 12
_____
Height of the *Pole* above the *Plain*	65 40

2. But

2. But if this Sum exceed 90 deg. then subtract it from 180 deg. and the Remainder shall be the Height of the *Pole* above the Plain.

	deg.	min.
Latitude 51 deg. 32 min. Compl.	38	28
Reclination	70	42
	Sum. 109	10
Which subtract from	180	00
There remains	70	50

Which 70 deg. 50 min. is the Height of the *Pole* above the *Plain*.

3. If the Sum of the Complement of the Latitude and the Reclination added together do make juſt 90 deg. then that *Plain* is a *Polar Plain*, and the Dial for ſuch a *Plain* muſt be made in all Reſpects as is directed in the 16th Chapter of the Firſt part of this Book.

SECTION VI.

Of East and West Direct Reclining Plains.

IN Eaſt and Weſt Reclining Plains (the Latitude of the Place, and Reclination being given) there are required the ſame three things as in North and South Erect Decliners, namely,

1. The Height of the Pole (or Stile) above the Plain.
2. The Diſtance of the Subſtile from the Meridian.
3. The Plain's Difference of Longitude.

Example, Of the Eaſt or Weſt Reclining Plain, Part I. Chap. 10. whoſe Reclination was

N   35 deg.

35 deg. 00 min. and Latitude 51 deg. 32 min.

1. *For the Height of the Pole or Stile above the Plain.*

As the Radius 90 deg.   10.00000

Is to the Sine of the Latitude 51 }
deg. 32 min.   } 9.89374
So is the Sine of the Reclination 35 d. 9.75859

To the Sine of 26 deg. 41 min.   19.65233
Which 26 deg. 41 min. is the Height of the Pole above the Reclining Plain.

2. *For the Distance of the Substile from the Meridian.*

As the Radius 90 deg.   10.00000

Is to the Tangent of the Lati-}
tude 51 d. 32 min.   } 10.09991
So is the Co-sine of the Reclina-}
tion 35 deg.   } 9.91336

To the Tangent of 45 deg. 52 min. 10.01327
Which 45 deg. 52 min. is the Substile's Distance from the Meridian.

3. *For the* Plain's *Difference of Longitude.*

As the Sine of the Latitude 51 deg. }
32 min.   } 9.89374
Is to the Radius 90 deg.   10.00000
So is the Sine of the Substile's Di-}
stance from the Meridian 45   } 9.85595
deg. 52 min.   }

To the Sine of 66 deg. 27 min   9.96221
Which 66 deg. 27 min. is the Plain's Difference of Longitude.

SECT.

SECT. VII.

Of South and North Declining Reclining Plains.

IN Declining Plains Reclining (besides the Latitude of the place, Declination and Reclination of the *Plain* ; (which are for the most part given) there must four Things be found before you can draw the Dial, *viz.*

1. The *Distance of the Meridian and Horizon.*
2. The *Height of the Pole or Stile.*
3. The *Distance of the Substile from the Meridian.*
4. The *Plain's Difference of Longitude.*

Of these Plains you have in the 20, 21, 22, 23, 24, and 25 Chapters of the first Part, six Varieties, which are all that in any Case may happen, *viz.* Three of South Declining Reclining, and as many of North Declining Reclining, I shall only instance in two of them, *viz,* one of a South Reclining Plain Declining Easterly, and another of a North Reclining Plain Declining Westerly. The Example of the South Recliner shall be that in the third and last Variety of South Decliners Reclining, and that is of a South Plain declining Easterly 30 deg. and Reclining 55 deg. as in Part I. Chap. 22.

N 2 L In

I. *In* South Decliners Reclining.

1. *For the Diftance of the Meridian from the Horizon.*

As the Radius 90 deg.   10:00000

Is to the Sine of the Reclination 55 deg.   }   9.91336

So is the Tangent of the Declination 30 deg.   } .   9.76144

To the Tangent of 25 deg. 19 min.   19.67480
Which 25 deg. 19 min. being taken from 90 deg. leaves 64 deg. 41 min. the Diftance of the Meridian from the Horizon.

2. *For the Height of the Pole (or Stile) above the Plain.*

This will require two Operations.
1. As the Radius 90 deg.   10.00000

Is to the Sine of the Diftance of the Meridian from the Horizon 64 d. 41 min.   }   9.95615

So is the Co-fine of the Reclination 35 deg.   }   9.75859

To the Sine of 31 deg. 14 min.   19.71474
Which 31 deg. 14 min. being lefs than the Latitude 51 deg. 32 min. fubtract it therefrom, and there will remain 20 deg. 18 min.

Then

Then say again,

2. As the Sine of the Distance of
the Meridian from the Horizon   9.95615
64 deg. 41 min.

Is to the Sine of the Arch last
found 20 d. 18 m.   9.54025

So is the Co fine of the Declination
60 deg.   9.93753

                     19.47778

To the Sine of 19 deg. 25 min.   9.52163

Which 19 deg. 25 min. is the Height of the
Pole or Stile above the Plain.

Note, That if the Arch found at the first of
these Operations be equal to the Latitude of
the place (as there it was lesser, *viz.* but 31
deg. 14 min.) then the Reclining Plain had
been an Æquinoctial Decliner, and must be
made as by the Precepts delivered in the 20th
Chap. of the first part.

3. *For the Distance of the Substile from the Me-*
ridian.

As to the Co-Tangent of the Declina-
nation 60 d.   10.23856

Is to the Sine first found in the last
proportion, *viz.* 31 deg. 14
min.   9.71477

So is the Tangent of the Height of
the pole above the Plain 19 d.
25 min.   9.54714

                     19.26192

To the Sine of 6 deg. 3 min.   9.02335

           Which

Which 6 deg. 3 min. is the Diſtance of the
Subſtile from the Meridian.

4. *For the* Plain's *Difference of Longitude.*

As the Sine of the Difference of the ⎫
   Arch firſt found, and the Lati ⎬ 9.54025
   tude of the place, *viz.* 20 d. 18m. ⎭

Is to the Radius 90 deg.   10.00000

So is the Sine of the Subſtile's ⎫
  Diſtance from the Meridian 6 ⎬ 9.02335
  3 min. ⎭
                                   ————

To the Sine of 17 deg. 42 min.   9.48310
Which 17 deg. 42 min. is the Plain's Diffe-
rence of Longitude.

II. In North Decliners Reclining.

In all theſe Plains (as well as in South Recli-
ners) four Things muſt be found (beſides the
Latitude of the place, and the Reclination of
the Plain, which are commonly given) before
the Dial can be drawn, and thoſe are the ſame as
in South Recliners, *viz.*

   1. *The Diſtance of the Meridian from the Ho-*
    rizon.
   2. *The Height of the Pole (or Stile) above*
    the Plain.
   3. *The Diſtance of the Subſtile from the Me-*
    ridian.
   4. *The* Plain's *Difference of Longitude.*

All theſe may be found by the following *Ca-*
nons or *Analogies.* And for an Example, I
ſhall make uſe of the North Plain declining
                             Weſterly

Westerly 60 deg. and Reclining 54 deg. as
in the last Example of North Recliners, Part
I. Chap. 25.

1. For the *Distance of the Meridian from the
Horizon.*

As the Radius 90 deg.   10.00000

Is to the Sine of the Reclination
54 deg.   9.90795
So is the Tangent of the Declina-
tion 60. deg.   10.23856

To the Tangent of 54 deg.
29 min.   10.14651
Which 54 deg. 29 min. being taken from 90.
deg. leaves 35 deg. 31 min. And that is the
Distance of the Meridian from the Horizon.

2. For the *Height of the Pole* (or *Stile*) *above
the Plain.*

This also will require two Operations.
1. As the Sine of the Declination 60 deg. 9.93753

Is to the Radius 90 deg.   10.00000
So is the Co-sine of the Distance of
the Meridian from the Horizon
54 deg. 29 min.   9.91059

To the Sine of 70 deg. 2 min.   9.97306
To this Sign of 70 deg. 2 min. add the Com-
plement of the Latitude 38 deg. 28 min.
the Sum will be 108 d. 30 min. and this
Arch (being above 90 d.) take it from 180 d.
so will there remain 71 d. 30 m.

2. As

2. As the Sine of the Arch firſt found 70 d. 2 m. }   9·97306

Is to the Sine of the Reclination 54 d. 0 m. }   9·90796

So is the Sine of the Arch laſt found 71 d. 30 m. }   9·97695

To the Sine of 54 d. 43 m.   9.91185

Which 54 d. 43 m. is the Height of the Pole or Stile above the Plain.

Note, That if the Arch firſt found, *viz.* 70 d. 2 m. had been juſt 90 d. the Plain then had been a polar declining Plain, the Subſtile and the Hour of Six being the ſame, and muſt be made by the precepts delivered in Part I. Chapter 23.

3. For the *Diſtance of the Subſtile and Meridian.*

As the Tangent of the Reclination 54 deg. }   10.13874

Is to the Sine of the Arch firſt found, *viz.* 54 d. 29 m. }   9·91059

So is the Tangent of the Height of the Pole above the Plain 54 d. 43 m. }   10.15021

                      20.06080

To the Sine of 56 deg. 42 min.   9.92206

Which 56 d. 42 m. or rather the Complement thereof to 180 d. *viz.* 123 d. 18 m. is the Diſtance of the Subſtile from the Meridian, according as you pleaſe to account it, either from the North, or from the South.

4. *For*

4. *For the Plain's Difference of Longitude.*

As the Sine of the Height of the }
Pole above the Plain 54 d. 43 m. } 9.91184

Is to the Tangent of the Di- }
stance of the Substile and Me- } 10.18251
ridian 56 deg. 42 min. }
So is the Radius 90 deg. 10.00000

To the Tangent of 61 deg. 48 min. 10.27067
Which 61 deg. 48 min. is the Plain's Diffe-
rence of Longitude counted from the North,
or the Complement thereof to 180 deg. *viz.*
118 d. 12 min. is the same Difference of
Longitude counted from the South.

SECTION VIII.

Of the Hour Distances upon the Plain.

Hitherto you have in a general, plain and ea-
sie Method, (and of all others the most ex-
act) delivered the Manner how to calculate the
Requisites belonging to all sorts of Plains, whe-
ther *Direct, Reclining, Declining,* or both. It
resteth now, to find the true Hour-Distances one
from another upon any of these *Plains,* and for
that (for all Dials which have Centers) there is
only one general Analogy or Proportion, and
that is this, Having found the *Plain's Difference of
Longitude* ; say,

As

As the Radius or Sine of 90 deg.

Is to the Sine or Height of the Pole or Stile above the Plain.

So is the Tangent of each Hour's Distance (upon the Æquinoctial) from the Subſtile.

To the Tangent of the same Hour's Diſtance upon the Plain counted from the Subſtile.

Now, (becauſe Examples do more confirm than barely Precepts) I ſhall by Precedent or Example make plain all that hitherto hath been deliver'd, and one ſhall ſerve inſtead of many, and that ſhall be in an upright or erect declining Plain, (which of all Dials are the moſt common and uſeful.) Suppoſe therefore,

In Latitude 52 deg. 40 min. *an erect Plain beholding the South, to decline Weſtward* 24 *Degrees.*

The Arithmetical Calculation.

By the Rules delivered in the III. Section of **theſe Precepts,** you ſhall find,

1. *The Height of the Pole (or Stile) above the Plain to be* 33 *deg.* 38 *min.*
2. *The Diſtance of the Subſtile from the Meridian to be* 17 *deg.* 14 *min. And,*
3. *The Plain's Difference of Longitude to be* 29 d. 15 m.

Theſe Requiſites being thus attained, the next Thing is to find the Hour Diſtances upon the Plain, which may be done by the laſt foregoing Analogy.

But

But firſt, you are to conſider the Quantity of the *Plain*'s Difference of Longitude, which here, in this Example, is found to be 29 deg. 15 min. And becauſe every Hour's Diſtance upon the Æquinoctial is 15 deg. Diſtance from the *Subſtile*, or Meridian of the *Plain* ; ſo 2 Hours is 30 d. Diſtance, and 3 Hours is 45 deg. Diſtance: This *Plain*'s Difference of Longitude being above 15 deg. (which is one Hour's Diſtance) and leſs than 30 deg. (which is two Hours Diſtance) the Subſtile (the *Plain* declining Weſterly) muſt needs fall between the Hours of 1 and 2 in the After-noon. Wherefore ſubtract 15 deg. (1 Hour's Diſtance) from 29 deg. 15 min. and there will remain 14 deg. 15 min. the Æquinoctial Di-ſtance of 1 a Clock from the *Subſtile*. Alſo from 30 deg. (which is two Hour's Diſtance) ſubtract 29 deg. 15 m. and the Remainder will be 00 d. 45 m. for the Equinoctial Diſtance of 2 a Clock from the Subſtile. Having found the two Æquinoctial Diſtances of the two next Hour-lines, on either ſide of the *Subſtile* (as of 1 and 2) the reſt are eaſily found by the continual Addition of 15 deg. and ſo is the Column of the Æquino-ctial Diſtances in the following Table made. Being thus prepared, the true Hour-diſtances from the *Subſtile* upou the Plain, may be eaſily attained by the foregoing Analogy. I will inſtance in one Hour's Diſtance for all, and give you the reſt in a Table : As,

Let it be required to find the Diſtance of one a Clock upon the Plain from the Subſtile, ſay,

2   As

As the Sine of 90 deg.   10.00000

Is to the Sine of the Height of the
Stile 33 deg. 38 min.   9.74341

So is the Tangent of the Equinoctial
Distance of 1 a Clock, *viz.* 14 d.   9.40478
15 min.

To the Tangent of 8 deg. 0 min.   19.14819

Which 8 d. 0 m. is the Distance of the 1 a Clock
Hour-line upon the Plain from the Substile.
And in the same manner may you find the Di-
stance of 2 a Clock to be 0 d. 25 m. Of 3 a
Clock 8 deg. 53 m. Of 4 a Clock 18 d. 14
m. and so the rest, as in the following Table
for every whole Hour. And if you desire halfs
and quarters of Hours, you must insert them
in the Column of Æquinoctial Distances, al-
lowing 7 deg. 30 min. for half an Hour, and
3 deg. 45 min. for a quarter, and so 15 deg.
for a whole Hour.

Hours	Æquinoctial Distances		True Hour Distances.	
	deg.	min.	deg.	min.
VIII	89	15	88	39
IX	74	15	63	1
X	59	15	42	57
XI	44	15	28	21
XII	29	15	17	14
I	14	15	8	0
II	0	45	0	25
III	15	45	8	53
IV	30	45	18	14
V	45	45	29	37
VI	60	45	44	41
VII	75	45	65	22

Substil.

Substil,

Thus

Thus have you the Arithmetical Calculation of the whole Dial ; it now remains to shew how these Hour-lines are to be transferred from the Table to the Dial-plain, which is to be done as followeth.

The Geometrical Projection.

First, (Upon your Dial-plain) draw an Horizontal-Line A B, and perpendicular thereunto another Line C D, for the Meridian and Hour-line of 12.

Secondly, Take 60 deg. out of your Line of Chords, and setting one Foot in C, with the other describe the Semicircle E F G.

Thirdly, Because the Distance of the Substile from the Meridian was found to be 17 deg. 14 min. Take 17 deg. 14 min. from your Line of Chords, and set *South Declining West* 24 d. Lat. 52 d. 40 m. Plate 6. *Fig.* 5. them upon the Semicircle from F to H, and draw the Line C H for the Substile.

Fourthly, The Height of the Stile being 33 deg. 38 min. set that Distance upon the Semicircle from H to K, and draw the Line C K for the Stile.

Fifthly, (Having Recourse to your Table) take 18 deg. 39 min. out of your Line of Chords, and set them upon the Semicircle from H to 8, and draw the Line C 8 for the Hour-line of 8 of the Clock.

Lastly,

		deg.	min.		
C 9	9	63	1	and set the same upon the Semi-circle on the Plain from H, to	draw the lines
C 10	10	42	57		
C 11	11	18	21		
C 12	12	17	14		
C 1	1	8	0		
C 2	2	0	25		
C 3	3	8	53		
C 4	4	18	14		
C 5	5	29	37		
C 6	6	44	41		
C 7	7	65	22		

Lastly from your Line of Chords, take
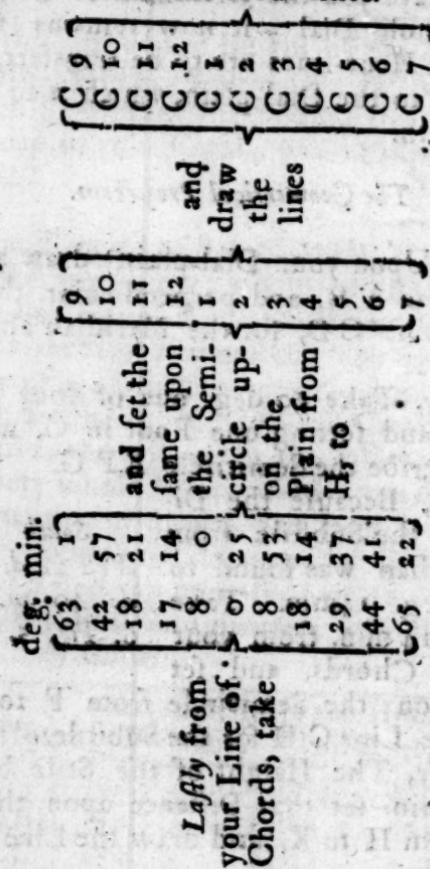
Thus is your Dial finished, only the Stile, which muſt be ſet to hang perpendicularly over the *Subſtile*, making an Angle at the Center of the Plain of 33 d. 38 m. equal to the Height of the Stile.

And thus have you an Abſtract of the whole *Art* of *Dialling*, after the moſt exact and compendious Way of Performance ; others may be more expeditious, but none more exact.

SECT.

SECTION IX.

IT will be to little purpose to be thus curious in finding of the true Positions of the Meridian, Stile, Substile and Hour-distances in all Plains, as in the foregoing Precepts is deliver'd, unless also we be as severe or strict in finding of the Site or Position of the *Plain*, upon which the Dial is to be made. For what will it signify to make the Dial true, and place it in a wrong Position? You are in the Geometrical Part of this Book taught how to find the Declination of any *Plain*, and for the finding of it, to attain the true Azimuth of the Sun is the chief Ingredient, and how to perform that Geometrically, is there taught two Ways. But that the like Exactness may be in the Performance of this also, I shall in this place (before I end) exhibit the manner of finding the Sun's Azimuth at any time, and in any place, by Arithmetical Calculation.

Example, In the Latitude of 51 deg. 32 min. the Sun having 17 deg. 56 min. of North Declination, and his Altitude 35 deg. Let it be required to find his Azimuth.

First, Add the Complement of the Latitude, the Complement of the Declination, and the Complement of the Sun's Altitude all into one Sum, and take the half thereof, from which half Sum subtract the Complement of the Declination, and note the Difference as here is done.

<div align="center">O 2</div> deg.

	deg.	min.			deg.	min.
Latitude	51	32			38	28
Declination	17	56	Complement		72	04
Altitude	35	00			55	00

Sum 165 32

half Sum 82 46

The Difference between the half Sum } 10 42
and the Compl.-of the Declinat on. }

Then will the Proportion be.

(1.) As the Radius 90 deg.   10.00000

Is to the Cofine of the Altitude }   9.91336
55 deg.   }
So is the Co-fine of the Latitude }   9.79383
38 d. 28 m.   }

To the Sine of 30 d. 38 min.   19.70719

(2. As the Sine of 30 deg. 38 min.   9.70719

Is to the Sine of the half Sum }   9.99653
82 d. 46 m.   }
So is the Sine of the Difference }   9.26873
10 d. 42 m.   }

19.26526
To this Sine   9.55807
To which add the Radius or *Sine* } 10.00000
of 90 d.   }

The Sum is   19.55807
The half Sum   9.77903
Which

Which is the Sine of 36 deg. 58 min. the Complement whereof is 53 deg. 2 min. and that doubled is 106 d. 4 m. which is the Sun's Azimuth from the North part of the Meridian, which if you take from 180 deg. there will remain 73 deg. 56 min. which is the Azimuth from the South. And thus may you find the Sun's Azimuth more exactly at any Time.

A

SUPPLEMENT

A

SUPPLEMENT

TO

Geometrical Dialling, &c.
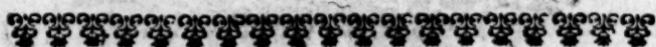
CHAP. I.

Of such Circles of the Sphere, as are described upon Sun-Dials.

MANY Astronomical Conclusions may be performed by describing the Circles of the Sphere upon the *Dial-plains* ; of which I have here made Choice of these following :

1. The *Parallels* of the *Signs*, shewing what part of the *Zodiack* the Sun is in at all times of the Year.

a

2. The *Diurnal Arches*, shewing the Length of the Day and Night throughout the Year.

3. The Hours from the *Sun's Rifing*, or *Setting*; or the *Babylonish* or *Italian Hours*.

4. The *Unequal, Jewish*, or *Planetary Hours*.

5. The *Azimuths*, or *Vertical Circles*, shewing in what Quarter of the World, or upon what Point of the *Mariner's Compaſs*, the Sun is at all Times of the Day.

6. The *Almicanter*, or *Circles* of *Altitude*; whereby the Proportion of Shadows to their Objects, or the Sun's Height may be known.

Of these ſome are great Circles of the Sphere, others ſmall: The great Circles in all Plains are repreſented by ſtrait Lines, as the Hour-lines themſelves are: The leſſer Circles are deſcribed by Conick Sections; and they are either *Parabolas, Hyperbolas*, or *Ellipſes*: Only the Parallels of the Signs, and the Diurnal Arches in *Polar Dials*, and the Parallels of Altitude in *Horizontal Dials*, are perfect Circles.

❀❀❀❀❀❀❀❀❀ ❀❀❀❀❀❀❀❀❀

CHAP. II.

How to deſcribe the Æquinoctial, the two Tropicks, and other intermediate Parallels of Declination, upon any Dial-plain.

THE two *Tropicks* being the Boundaries of the Sun's Courſe, (for he never exceeds thoſe Limits,) I count it beſt, firſt to ſhew how they may be deſcribed; for that between them all other Circles (either great or ſmall) muſt be

pro-

projected, and the manner of defcribing them upon feveral *Plains* is various.

In a *Polar Dial* they are perfect Circles, and fo are eafily defcribed by Circles drawn about the Foot of the *Perpendicular Stile* ; in all other *Plains* they are Sections of a *Cone*.

I. *In the* Æquino&ial, *and direct Eaft or Weft Dials.* Plate 9.

Let an Example be of a direct Eaft Dial, in the Latitude of 51 d. 32 m.

How to defcribe the Hour-lines upon thefe Plains, is fhewed in the 6th Chapter of this Book. Wherefore fuch a Dial being drawn as in Figure I. through the Foot of the *Perpendicular Stile* at E, draw a right Line M E N, parallel to the Horizon ; for the Horizontal Line in all Plains, muft be drawn through the Foot of the *Perpendicular Stile*, and alfo through the Point where the *Æquino&ial Circle* crofleth the Hour-line of Six. Your *Dial*, with the Æquino&ial Line thereof H E S, being drawn, come we to defcribe the *Tropicks :* To effect which,

Firft, Upon a Piece of fine Card-Paft-board, draw a right Line O R, as in Figure II. reprefenting the Æquino&ial Line in your Dial ; and (becaufe the *Tropicks* are 23 deg. 30 min. diftant from the Æquino&ial) with 60 deg. of your Chords, upon the Point O, defcribe an Arch of a Circle, and upon it fet 23 deg. 30 min. from R to S, and draw the Line O S, reprefenting the two *Tropicks* ; and this Angle S O R, I call a *Trigon*.

Secondly, Out of your Dial take the Length of the *Perpendicular Stile* E G, and fet it upon the

                                                  Tri-

Trigon from O to P, and draw the Line P 6 perpendicular to O R: Also,

Take the Distance from G, to the Intersection of the Hour-line of

7	with the Æqui-	*q*	and	*q*	7	Perpen-
8	noctial, and set	*r*	draw	*r*	8	dicular
9	them upon the	*s*	the	*s*	9	to O R.
10	Trigon from O	*t*	lines	*t*	10	
11	to	*v*		*v*	11	

Having thus prepared the Trigon, out of it take the Distance P 6, and set it upon the 6 a Clock Hour-line from E to *c* : —— Also take the Distance *q* 7, and set it upon your *Plain* from V to *b*, and from VII to *d* : —— Also take *r s*, and set it on your *Plain* from IV to *a*, and from VIII to *e* : —— Likewise take the Distance *s* 9, and set it upon your *Plain* from IX to *f* :—— Also take the Distance 10 *t*, and set it from X to *g* : Lastly, take *v* 11, and set it on the *Plain* from XI to *h*.

These Points *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, are the Points through which the Tropick of *Cancer* must be described ; wherefore, if through them a Line be drawn with an even Hand, making no Angles, that shall be the Tropick of *Cancer*.

The Tropick of *Capricorn* may be described in the same manner, if for from your Trigon you take

The	8	*r*	And set it up-	VIII		*k*
	9	*s*	on your Di-	IX		*l*
Distance	10	*t*	al Plain	X	to	*m*
	11	*v*	from	XI		*n*

Those shall be the Points through which the Tropick of *Capricorn* must be described ; wherefore

fore if through *k l m n*, a Line be drawn with an even Hand, it shall represent the Tropick of *Capricorn.*

And whereas I said before, that the two Tropicks are the Boundaries of the Sun's Course, you are to note, That

When the Sun is in

Capricorn,	which is about	*Dec.* 11.	the Shadow of the top of the *Stile* will pass along those respective Lines.
Aries, or		*Mar.* 10.	
Libra,		*Sept.* 12.	
Cancer,		*June* 11.	

And according to this Method may any other intermediate Parallels of Declination be inserted ; as for Example : Suppose I would insert the Parallels of the Sun's Entrance into the 12 *Signs, Aries* and *Libra* are inserted already, also *Cancer* and *Capricorn* ; for the rest, as when the Sun enters into

Taurus,	the Sun hath 11 deg. 30 min.	of Declination,
Virgo,		
Scorpio,		
Pisces.		
Gemini,	the Sun hath 20 deg. 12 m.	
Leo,		
Sagittarius,		
Aquarius		

Wherefore take 11 deg. 30 min. and 20 deg. 12 min. out of your Line of Chords, and set them upon the Arch R S of your Trigon, from R to V and X, and draw the two Lines O U and O X.

These

These *Parallels* being thus put into your Trigon, they may be transferred into the *Dial-plain*, in all respects, as the Tropicks were; and as you see done in the Figure I.

II. *In a direct North or South Dial. Plate 9. Fig. 3.*

Having drawn your Dial, as is taught in Chapter V. together with the *Stile*, your first Work must be to proportion your Stile to your Plain; which to do, assume any convenient point in the *Substile* (here the Line of XII.) for the farthermost Tropick, as here the Point ♋; then the *Stile*'s Height being 38 deg. 28 min. add 23 deg. 30 m. thereto, the Sum is 61 d. 58 m. and that is the Meridian Altitude of the Sun when he enters *Cancer*, and the Complement thereof 28 d. 2 m. wherefore, upon the Point *Cancer*, make an Angle B ♋ A to contain 28 d. 2 m. so shall the Line ♋ A cut the Axis of the *Stile* O A, in A; then from A let fall a Perpendicular to O ♋, as A B; and so is your Stile proportioned to your *Plain*; and the Line C B D, (being drawn parallel to the Horizon, through the point B) shall be the Horizontal Line of the *Plain*.

This done, prepare a Trigon, as Figure IV, in which make E F equal to O B, and E G, to A B, the Triangle E F G in the Trigon, equal to the Triangle of the Stile O A B in the *Dial.*

From the Point E draw a Perpendicular to E F, as E 12, for the Æquinoctial; and upon E, with 60 deg. of your Chord describe an Arch H 12 L, and upon it set 23 deg. 30 min. from 12 to H and L, drawing the Line E H for the Tropick of *Cancer*, and E L for the Tropick of *Capricorn.*

Draw

Draw the *Subſtilar* Line F G quite through the Trigon, croſſing the Æquinoctial in *a*, and both the Tropicks.

This done, out of your Trigon take the Diſtance from F to *a*, and ſet it upon the *Dial-plain* from the Center O to *c*, through which Point *c* draw the right Line ♈ *c* ♎ for the Æquinoctial : Then from O, the Center of your Dial, take the Diſtance to the Interſection of the *Hour-line* of 11 or 1 with the Æquinoctial, and ſet that Diſtance upon the Trigon from F to *b*; ——— Alſo take the Diſtance from O, to the Interſection of the Hour-line of 10 or 2, and ſet it from F to *c* : ——— Likewiſe the Diſtance from O, to the Interſection of the Hour-line of 9 or 3, ſet from F to *d* : ——— And laſtly, the Diſtance from O to the Interſection of 8 or 4, with the Æquinoctial, ſet from F to *e* ; and draw the Lines F *a*, F *b*, F *c*, F *d*, F *e*, through the Trigon, marking them with 12, 11, 10, 9, 8, and 1, 2, 3, 4, *&c.*

Now to find the Points upon the Plain, thro' which the Tropicks muſt paſs ;

The Diſtance from F to

12	will reach	♋	on the	12	
11	from O,	*f*	Hour-	11	1
10	the Center	*g*	Line	10	2
9	of the Dial	*h*	of	9	3
8	to				

Through which Points the Tropick of *Cancer* muſt be drawn with an even Hand , And,

The

The Diftance from F to

12	will reach		♑			12	12
1	from O, the	k		upon the		11	1
2	Center of	l		Hour-lines		10	2
3	the Dial,	m		of		9	3
4	to		♑			8	4

Through which Points the Tropick of *Capricorn*
muft be drawn.   And thus have you the Æqui-
noctial, and the two *Tropicks* defcribed upon a
direct South *Plain*.

III. *How to defcribe the Æquinoctial. and the two*
Tropicks into any upright declining Plain ; or
into fuch as both Recline *and* Decline.

Our Example fhall be in an Upright Plain,
declining from the South Weftward 30 deg.
The making of thefe Dials is taught in the 7th
and 8th Chapters of this Book : Wherefore, ha-
ving drawn fuch a *Dial*, with the *Stile* and *Sub-
ftile* in a due Pofition, you fhall find the Height
of the Stile to be 32 deg. 36 min.

Firft, Make an *Horizontal Dial* for the Latitude
of 32 deg. 36 min. as is the *Declining Dial, Fig.* 5.
where the Subftilar-line is taken for the Hour-
line of 12, as it is there marked, and the other
pricked Lines, and the Hour-lines of an *Horizon-
tal Dial* for the Latitude of 32 deg. 36 min. Now
if according to the Directions of the foregoing
Section, you make a *Trigon*, and infert the Æ-
quinoctial and *Tropicks* ; and afterwards expunge
the obfcure Lines of the *Horizontal Dial*, the Æ-
quinoctial, *Tropicks*, and *Horizontal Line* will be
the fame, as if they had been inferted from the
Hour-lines belonging to the Plain.

P   And

And as the *Tropicks* were deſcribed, ſo like-
wiſe may the Parallels of the Sun's Entrance
into the other Signs, be inſerted, if into your
Trigon you put the Arches of their Declina-
tions from the Æquinoctial, namely, 11 deg.
30 min. and 20 deg. 12 min. And ſo are the
Parallels of the Signs put into this Dial, *Pl.* 10.
Fig. 5.

And in any *Dial* alſo may the *Diurnal Arches* be
deſcribed, if you put into the Trigon ſuch
Declinations, as the Sun hath from the Æqui-
noctial, when the Day is either

				deg.	min.
♈	♋			23	30
8	16	Hours		21	40
9	15	long,		16	55
10 or	14	as		11	37
11	13			5	55
12	12			00	00

And ſo are the *Diurnal Arches* put into the South
Plain, repreſented by the Pricked Lines there,
in Fig. 3. and the Trigon thereunto belong-
ing. Fig. 4. both in Plate 9.

CHAP. III.

*How the Hour-lines from the Sun's Riſing and Setting
are to be inſcribed into all ſorts of* Dial-plains.

THE Hour-lines from Sun-Riſing are called
the *Babyloniſh Hours*, for that they begin
their Day at the Sun's Riſing ; and the Hours
from

from Sun-Setting are called the *Italian Hours*, for that they count their Time from the Setting of the Sun the Day preceeding.

The Manner how to infcribe thefe Hours, is the fame in all *Plains*, and is eafily performed : And becaufe that upon a full *South*, or *Horizontal Plain*, they will appear moft uniform ; I have therefore made Choice of a direct South Dial, as is Fig. 3. Plate 9. to infcribe them :

Your *Dial* being drawn, and the *Æquinoctial* ♈ ♎, and the 2 *Tropicks* ♋ ♋, and ♑ ♑, and the *Horizontal Line, Sun Rife, Sun Set* ; you muft (by the laft Chapter) defcribe two obfcure Parallels of Declination, one when the Day is 8 Hours long, as ☉ 8 ☉, and the other when the Day is 16 Hours long, as ✳ 16 ✳: the *Æquinoctial* being the Parallel when the Day is 12 Hours long.

Being thus far prepared, the Infcription of thefe Hours will be very eafie ; for it is plain, that when the Day is but 8 Hours long, the Sun rifes at 8 in the Morning ; and the firft Line after the Sun's-Rifing is 9 in the Morning : ——— Alfo when the Day is 12 Hours long, the Sun rifes at 6 in the Morning, and the firft Hour after is 7 in the Morning ;——— Laftly, When the Day is 16 Hours long, the Sun rifes at 4 in the Morning, and the next Hour after is 5 in the Morning : ——— And all the reft as in the following Table.

Length

	Length of the Day.		
	I VIII I	XII I	XVI
I	9	7	5
II	10	8	6
III	11	9	7
IV	12	10	8
V	1	11	9
VI	2	12	10
VII	3	1	11
VIII	4	2	12
IX	5	3	1
X	6	4	2
XI	7	5	3

(left margin, vertical: Hours from Sun Rising.)

Wherefore a ſtrait Line drawn through the Interſections of theſe Hour-lines, with the Parallels of 8, 12, and 16 Hours, ſhall be the firſt Hour after the Sun Riſing all the Year long.

In like manner, if you would inſert the 7th Hour after the *Sun Riſing* : By the Table you ſee that in the *Parallel* of VIII Hours for the Length of the Day, the ſeventh Hour from Sun-Riſing is 3 in the Afternoon ; therefore obſerve where the Hour-line of 3 croſſeth the Parallel of VIII Hours, which is at *a*. —— Alſo by the Table you ſee that in the *Parallel* of XII Hours, for the Length of the Day, the ſeventh Hour from *Sun-Riſing* is 1 in the Afternoon ; wherefore obſerve where the Hour-line of 1 croſſeth the Æquinoctial, which is at *b*.—— *Thirdly*, By the Table you ſee, that in the Parallel of XVI Hours for the Length of the Day, the ſeventh Hour from the Sun's Riſing is 11 in the Forenoon ; and therefore obſerve where the Hour-line of

XI

XI croſſeth the *Parallel* of XVI *Hours* for the Length of the Day, which is at *c* ; ſo ſhall a right Line, drawn through theſe three Points *a*, *b*, *c*, be the ſeventh Hour after the Sun's Riſing throughout the Year : And thus by the help of this little Table, may all the Hour-lines from the Sun's Riſing be drawn as you ſee them drawn and numbred, as in *Fig.* 3. *Plate* 9.

In the ſame manner, as the Hours from the Sun's Riſing (which are the *Babyloniſh* Hours) were drawn, may the Hours from the Sun's Setting, (wh'ch are the *Italian* Hours) be drawn. The Difference being only in numbering of them ; the Hours from Sun Riſing being numbred from the Weſt End of the *Horizontal Line,* by 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 : And the Hours from Sun Setting from the Eaſt End of the *Horizontal line* backwards, by 23, 22, 21, 20, 19, 18, 17, 16, 15, 14, 13 ; all which is evident in the fore-named Fig. 3.

COROLLARY.

The Hour-lines from Sun Riſing and Sun Setting being deſcribed upon any *Dial-plain*, as is before taught, there will by their correſpondent Interſections one with another, be Points produced, through which if Lines be drawn with an even Hand, the ſame ſhall be the Parallels of the Length of the Day, and ſuch are the pricked Lines in Fig. 3, numbred upon the Meridian-line of the Dial, by 8, 9, 10, 11, 12, 13, 14, 15, 16.

P 3 CHAP.

CHAP. IV.

Of the Jewish, *or Old* Unequal, *or* Planetary-hours, *and how they may be inscribed upon any Dial-plain.*

THE Ancients Account of their Day, was from the Sun's Rising in the Morning, till its Setting in the Evening, which Space of Time they did divide into 12 equal Parts, were it long or short : So that in the Summer all that Time that the Sun hath North Declination, the *Hours* of their Day were longer than a common equal *Hour* ; and in the Winter, when the Sun hath South Declination, the *Hours* of their Day were shorter than a common *Hour* ; but when the Sun is in the *Æquinoctial,* their *Hours* are equal to our common *Hours.*

The Inscription of these *Hour-lines* into all sorts of Plains, is very easy, being much like the Inscription of the *Italian* and *Babylonish* Hours, taught in the last Chapter.

Having

The Jewish Hours.	The Parallel of 15 Hours.		Æqui-noctial.	The Parallel of 9 Hours.	
	Ho.	Min.		Ho.	Min.
I	5	45	7	8	15
II	7	0	8	9	0
III	8	15	9	9	45
IV	9	30	10	10	30
V	10	45	11	11	15
VI	12	0	12	12	0
VII	1	15	1	0	45
VIII	2	30	2	1	30
IX	3	45	3	2	15
X	5	0	4	3	0
XI	6	15	5	3	45
XII	7	30	6	4	30

Having drawn your Dial with *Hours, Halfs,*
and *Quarters*; and also the *Æquinoctial,* the two
Tropicks, and *Horizontal* Line; and also the *Parallels* of the Length of the Day, as is done in *Fig.*
6. *Pl.* 10. which is a South Dial declining Eastward
15 deg. you must make Choice of two *Parallels* of
the Length of the Day, which must both of
them be equidistant from the *Æquinoctial,*
which let be the Parallels of 9 *Hours,* and 15
Hours, for those two Parallels are most convenient for this purpose; because the *Jewish Hours*
in those Parallels will justly fall upon the even
Hours, Halfs, or *Quarters* : Now the Points thro'
which the *Jewish Hours* are to be drawn, this
Table will direct to; wherein you see, that the
first *Jewish Hour* is to be drawn through 5 *Hours,*
45. min. in the Parallel of 15 *Hours,* through 7 in
the Æquinoctial, and through 8 *Hours* and 15
min.

min. in the Parallel of 9 *Hours.*——In like manner the second *Jewiſh Hour* muſt be drawn thro' the Interſection of the 7 *Hours* in the Parallel of 15 *Hours,* through 8 in the Æquinoctial, and through 9 in the Parallel of 9 *Hours :* And ſo muſt all the reſt of them be deſcribed as the Table does direct, and as you ſee done in *Fig.* 5. And in this manner, by help of this Table, may they be deſcribed in all ſorts of *Plains,* whether Direct, Reclining, or Declining.

C H A P. V.

How the Azimuths, or Vertical Circles are to be in-ſcribed upon Dial-plains.

THE Azimuths are great Circles, and being projected upon all Plains, become ſtrait Lines ; and they are variouſly deſcribed, according as the *Plain* is ſituated ; Particulars of which follow :

S E C T I O N I.

On an Horizontal Plain.

IN theſe Plains the Azimuths are moſt eaſily inſerted : For, your *Dial* being drawn, with the *Tropicks* and *Æquinoctial* thereupon, you have no more to do, than upon the Foot of the Perpendicular Stile at O (in Fig. 7.) as a Center, to deſcribe

defcribe a Circle, as *S* ✿ *N* ✿, which you may divide into 32 equal Points (beginning at N) anfwering to the 32 Points of the *Mariner's Compafs*, (or elfe you may divide it into 90 equal parts, or degrees) noted with ✳ ✳ ✳, &c. and through thofe points draw ftrait Lines from O, the Foot of the perpendicular Stile, and they fhall be the true Azimuths upon the *Horizontal Plain*; which you may denominate by *South*, *S* by *E*, *S S E*, *S E* by *S*, &c. as you fee done in *Fig.* 7. *Pl.* 10.

SECTION. II.

Upon an Erect, Direct Eaft, *or* Weft Plain, Plate IX. Figure I.

HAving made an Eaft *Dial*, and therein inferted the Æquinoctial, the two Tropicks, and the *Horizontal-line*, you may proceed to the Infcription of the Azimuths in the manner following.

Upon the Point E, of the *Horizontal-line* of the Plain M E N, erect the Perpendicular E Q, equal to E G, (the height of the Stile of your Dial) and upon Q, as a Center, defcribe the Quadrant Q E L, and divide it into 8 equal parts, reprefenting one Quarter of the Mariner's Compafs, and from Q, through thofe Points, draw Lines to the *Horizontal-line* M E N, noting them with ⊙ ⊙ ⊙ ⊙ ⊙ ⊙; from which Points let fall Perpendiculars from the *Horizontal-line*, and they fhall be the Azimuths between the South and the Eaft; —— And for thofe Points which fall

between

between the East and the North ; namely, *E* by
N,——— *E N E*,——— *N E* by *N*. ———the same
Distances being set upon the *Horizontal Line* from
E, towards the Left hand, as the three first A-
zimuths, *E* by *S*, ——— *E S E*, ——— *S E* by *E*,
were towards the Right Hand, shall give the
three points ☉ ☉ ☉ on the Left hand of E. ;
through which points also Lines drawn perpen-
dicular to the Horizon, shall be the Azimuths,
or Points of the Compass between the East and the
North : As in the Fig. I. And as the East Dial
contains the Azimuths between the South and the
East : The West Dial must contain those between
the South and the West.

SECT. III.

Upon a direct South upright Plain. **Plate IX. Fig. III.**

THE Dial, with the Æquinoctial, the two
Tropicks, and the Horizontal Line described
thereon, the Azimuth may be inserted thereon
as followeth :

First, Take the Length of the perpendicular
Stile of your Dial A B, and set it upon the Me-
ridian of your Dial from B to G.

Secondly, With the Distance G B, upon G, de-
scribe the Semicircle E B F, which divide into
16 equal parts, (if you will) but I have here di-
vided it but into 8, to shew the manner of the
Work, in the Points * * * *, &c. thro' which
Points from G, draw obscure Lines, extending
them till they touch the Horizontal Line of the
Plain

Plain C B D ; now if from thefe Points of touch-
ing you draw Lines perpendicular to the Hori-
zontal Line between the Tropicks, or Parallel
to the Line of 12, they fhall be the Azimuths
required.

I have not drawn the Lines themfelves in
this Fig. 3. becaufe the Plain is full
enough of Lines already.

S E C T. IV.

Upon a South Declining Plain· Plate X. Fig. VI.

A N Example. fhall be of a South Plain, de-
clining Eaftward 15 deg.
Such a Dial being drawn, and the *Æquinoctial*
Tropicks, and the Horizontal Line infcribed there-
on : Upon the Point B of the *Horizontal* Line
erect the Perpendicular B C, equal to B O, the
perpendicular Stile of your Dial ; upon which
Point C defcribe the Semicircle R B S ;
which done, lay a Ruler to C, and the Point
☉, where the Hour-line of 12 croffeth the *Hori-*
zontal Line, and where the Ruler cuts the Semi-
circle R B S, at that Point begin to divide it into
16 equal Parts, at the Points * * *, &c. and
from the Center C draw Lines through thefe
Points, extending them till they touch the *Ho-*
rizontal Line D E in the Points *a b c d e f g h i k*
and *l,* through thefe Points right Lines being
drawn parallel to the Meridian, fhall be the A-
zimuths defired, which you muft number ac-
cording

cording to the Situation of the Plain : Namely, the Weſtern Azimuths on the Eaſt Side of the Meridian, and the Eaſt Azimuths on the Weſt Side of the Meridian, as you ſee them numbred in Fig. 6. Plate 10.

✳✳✳✳✳✳✳✳✳✳✳✳✳✳ ✳ ✳✳✳✳✳✳✳✳✳✳✳✳✳✳✳✳✳

CHAP. VI.

How to inſcribe the Circles of the Sun's Altitude into Dial-Plains.

THE *Almicanters*, or Circles of Altitude, in the Sphere, have the ſame Habitude to the Azimuths, or Vertical Circles, as the *Parallels* of Declination have to the Meridians, or Hour-circles : And therefore, the *Æquinoƈtial* it ſelf, and all the *Parallels* of Declination in a *Polar Plain*, are perfeƈt Circles, and ſo are the *Almicanters*, or Circles of Altitude upon an *Horizontal Plain*, as in Plate 10. Fig. 7.

Horizontal Plains, which lie *Parallel* to the *Horizon*, have the Zenith for their *Poles* ; ſo that for the Inſcription of them upon theſe *Plains*, the Foot of the perpendicular Stile muſt be the Center upon which to deſcribe them.

For the Numeration of theſe Circles, when they are deſcribed, there are two Ways moſt in Uſe : The one by Degrees and Minutes of the Sun's Altitude ; the other according to the Proportion that the Height of any upright Objeƈt (as a Houſe, Steeple, *&c.*) bears to the Shadow of it : The laſt of which I have here followed in this Figure 7. where the Circles of

Altitude

Fig. I.
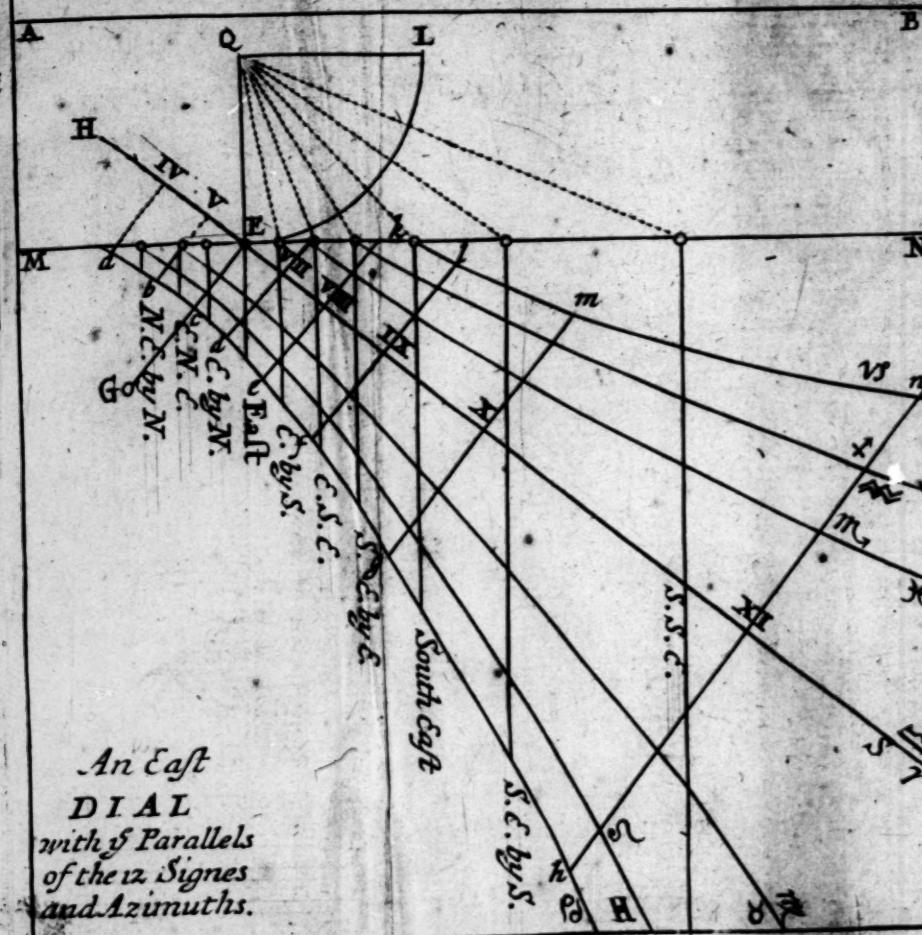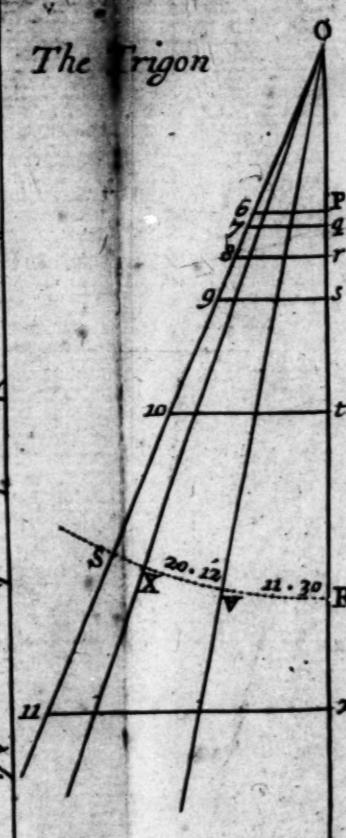
A   Q   L   B

H

IV

V

M   N

m

VS

N. C. by N.
N. E. C.
C. by N.
East
C. E. by E.
E. S. C.
S. E. by E.

South Eaſt

S. E. by S.

S. S. C.

XI

H

An Eaſt
DIAL
with 5 Parallels
of the 12 Signes
and Azimuths.

Fig. II.

The Trigon

O

6
7
8
9

P
q
r
s

VS   n

10   t

S

20. 12   11. 20

X   R

11   y

Fig. III.

VI   VI

E   O   F

G

VII   V

C   Sun Riſe   VS   Sun Set   D

1   23

VIII   IV

4   20

IX   III

h   h

X   XI   XII   I   II

Fig. IV.

Trigon

E   Axis   F

Subſtile

12

11

10

H   L

16   15   14   13   12   11   10   9   VS
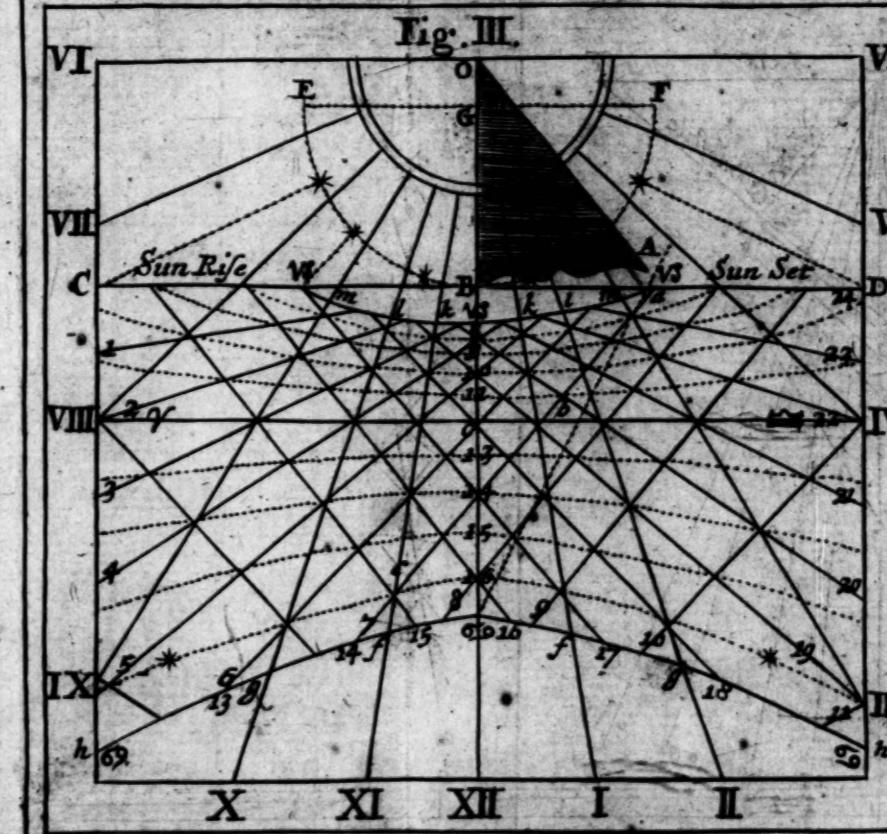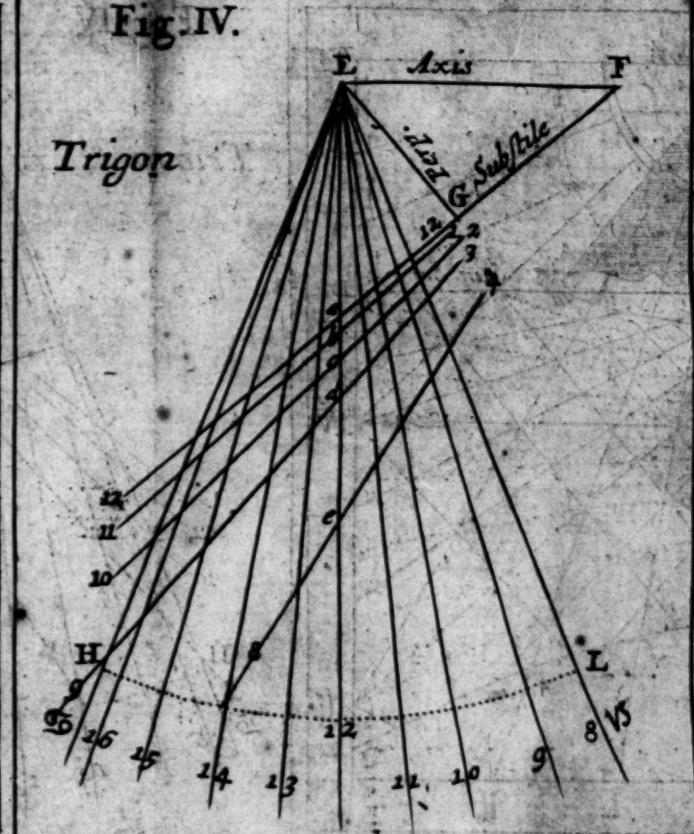
Altitude are equal, double, triple, and quadruple to the Altitude of the perpendicular Stile.

The Inscription of these Circles into all other *Plains*, are, in a kind, the same with the Inscription of the *Parallels* of Declination : Only, whereas in inscribing of the *Tropicks*, and other *Parallels* of Declination, you take the *Hour-lines* out of the *Dial-plain*, and put them into a Trigon; so in the Inscription of these you must take the Azimuth Circles out of your *Plain*, and put them into a Trigon, and from thence transfer them back again to your *Plain*, as in the other : And as the *Hour-lines* in the other, must be first drawn upon the *Plain*; so in this must the Azimuths be first inscribed : And because these Circles of Altitude are smaller Circles of the *Sphere*, as the Tropicks and Parallels of Declination were, they will upon all *Plains* (the *Horizontal* excepted) be *Conick* Sections.

CHAP. VII.

A general and easy Way to project Hour-lines upon all kind of Superficies, without any Regard had to their standing, either in Respect of Declination, Reclination, or Inclination.

IF a Point be assigned upon any Superficies, flat, or curved, one or more, wherein the *Hour-lines* and *Axis* shall concur; how to project the Hours to that Point, and to set up an *Axis* after the ordinary Manner, to give Shadow to them, without any Knowledge how the Dial

Q   standeth

ftandeth in refpeft either of Reclination, Declination, or Inclination.

Firft, To the *Point* affigned (upon any Side of it) by the help of a Semicircle, or other Level, ftretch out an Horizontal Thread, ferving for the *Horizontal-line* ; which Line need not be one fingle Line, but may be turned at one or more Angles, provided that it lie (all the parts of it) totally in the Superficies of the *Horizon.*

Secondly, With a perpendicular Thread held up, projeft the Sun upon the affigned Point, and into the *Horizontal* Thread, and ftick in a Pin, or make a Mark upon the fame *Horizontal-line*, through which the Shadow cutteth, and at the fame Inftant alfo take the Sun's Altitude.

Thirdly, By the Altitude taken find out the Sun's Azimuth ; this Azimuth, whatever it be, is reprefented by the Mark formerly made in the *Horizontal-line* or Thread.

Fourthly, Apply a *Paft-board* to the affigned Point, and hold it flat, that it may anfwer to the *Horizontal Thread* alfo ; and upon this *Paft-board* protraft your Azimuth by a Thread extended from the Point affigned for the Center to the Mark upon the Horizontal Thread. Which done,

Fifthly, By help of that Azimuth upon the *Paft-board*, protraft the Meridian-line, obferving the true Coaft and Quantity of the Angle from the Azimuth ; and to the Meridian thus found, defcribe an Horizontal Dial for the Place.

Sixthly, Apply the *Paft-board* to its place again, all things ftanding right as before ; projeft all the Hours into the *Horizontal Thread* from off the *Paft-board*, and fet Marks upon the fame Line ; for the Point of each feveral Hour, which Marks
, may

may be little Knots to flip to and fro upon the fame Thread.

Seventhly, Project the *Meridian Point* by a perpendicular Thread upon fome Object into that place, whereabouts you imagine the Axis of the World would pafs, above or below, from the point affigned for the Center.

Eighthly, With your Semicircle, (or a String and Quadrant) elevated or depreffed, (as it fhall be required) from the point affigned for the Center, according to your Latitude, project the *Pole* of the World.

Ninthly, Extend a Thread from the *Point* affigned for the Center to the *Poles* of the World, which fhall reprefent the *Axis.*

Tenthly, By the *Point* upon the Horizontal Thread, and this *Axis,* (either by your Eye, laying the *Axis* to the Hour-points, or laying the Hour-knots to the *Axis,*) you may project all the Hours, and draw them : ———— Or elfe you may let the *Axis* alone, and content your felf with the *Pole-point* projected into the Meridian : For if from the *Point* affigned to be the Center, or Meeting of the *Hours,* and *Axis,* you extend a Thread to each *Hour-point* in the Horizontal-line, and do repofe (with your Eye) the fame Thread upon the *Pole-points* ; then fhall the Shadow of the Thread give you that Hour-line ; and do fo in all the reft.

Eleventhly, Your Thread or *Axis* lying in its true Situation, you may eafily fit an Axis to the fame Pofture. If your Dial be defcribed upon a plain Superficies, you may then (by one fide of a Square, applied to the Thread or *Axis,* and the other fide lying upon the *Plain*) find out the Subftile, and meafure from it the Elevation of the *Plain.* ———— But if the Dial be defcri-

Q 2

bed

bed upon a curved Superficies, you muſt be con-
tent to ſet up your *Axſs* by the Direction of the
Thread only.

Twelfthly, This *Point* aſſigned for the Center,
being a *Point* of the *Axis*, is, as it were, the *A-
pex* of the *Gnomon,* unto which all the Work is
projected : But if it be required to ſet up
an *Axis* to ſuch a Superficies, upon which the
Hours and *Axis* will not meet in any tolerable
manner, becauſe perhaps the *Axis* may be but
of a very ſmall Elevation above the Superficies,
and yet an *Axis* is required, in this caſe ſet up any
point (of Wire, or ſuch like) of ſuch Diſtance
from the Superficies, as that the *Hours* and *Ax-
is* may be diſtinct, and through that point let it
be required to make the *Axis* paſs ; you have no
more to do but only to project to this point as
before, by letting the Shadow of a perpendicular
Thread paſs through that point, and noting the
ſame upon the *Horizontal Thread,* and counting
that End of the Wire as your Center, proceed
as before ; for the Thread that lies to project
the Hours is a Pattern for the *Axis.*

This Way is general, ſerving to project the
Hour-lines upon many Superficies, be they
plain or curved, and however ſituate, whe-
ther contiguous or ſeparate, and that with-
out any laborious Inquiſition after any of their
Situations in reſpect of Declination, Reclina-
tion, or Inclination.
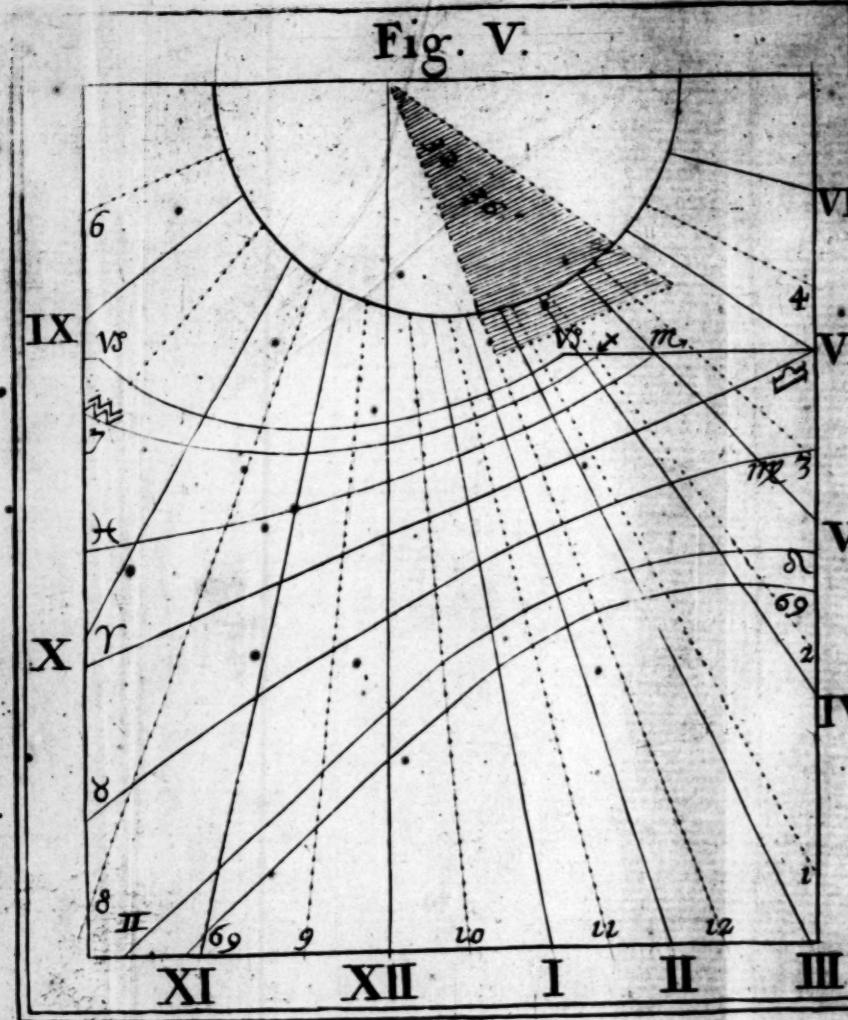
CHAP.

Fig. V.

A Declining Diall, with Parallels of the Length of y Day, Azimuths, and Iewish Hours.

Fig. VI.

Fig. VII.

An Horizontall Diall with the Tropicks, Azimuths and Parallels of Altitude.

plate 10. page 170.
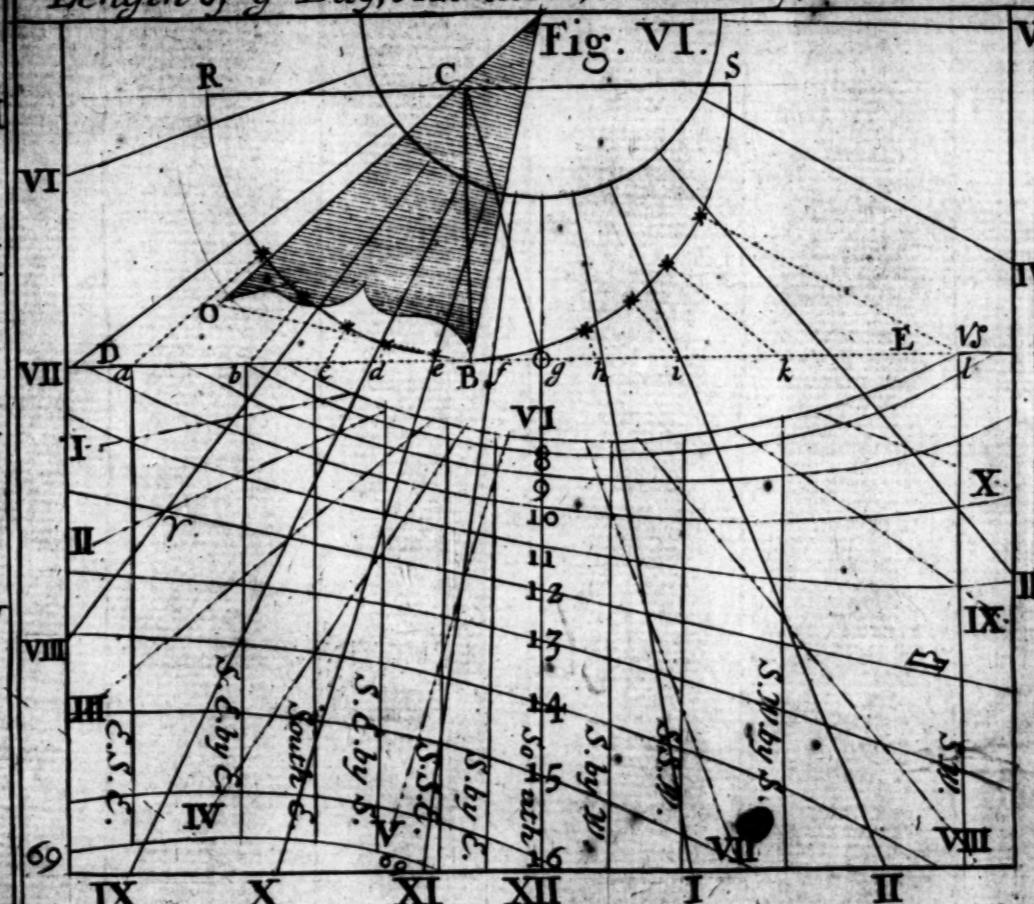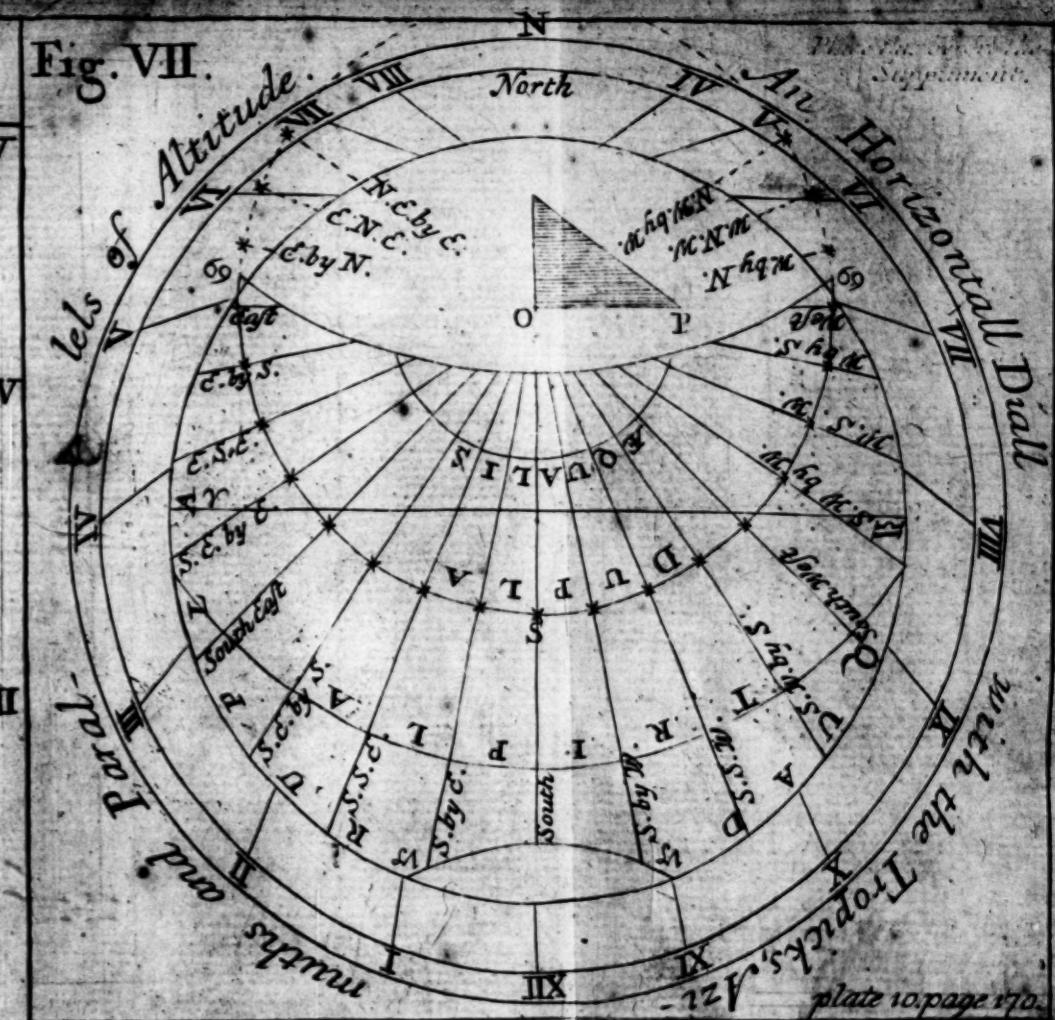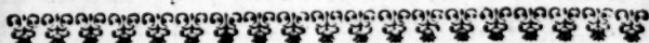
CHAP. VIII.

How from a Glass Horizontally placed, to Reflect Hours upon any Superficies, flat or curved, one or more.

FIRST, The Glass being placed truly *Horizontal*, obſerve the Spot of Light that the Sun caſts, and make a Mark at it.

Secondly, And obſerve immediately the Sun's Altitude, and find the Azimuth.

Thirdly, Then extend an *Horizontal* thread in the ſame Level with the Glaſs but within the Room.

Fourthly, Project the Azimuth into the *Horizontal Thread*, by holding up a *Perpendicular* Thread in ſuch a place, that tho' it hang at Liberty, you may at once diſcern both the Mark of the Spot of Light, and the Glaſs likewiſe ; and then obſerve where the perpendicular Thread ſeems to cut the *Horizontal Thread*, and at that apparent Interſection, make a Mark upon the *Horizontal* Thread for the Azimuth.

Fifthly, Apply a *Paſt-board* to the Glaſs, ſo that it may be ſtayed upon ſome Reſt, that after it is taken away, it may be reſtored into its place again with all Exactneſs : Let it be alſo placed *Horizontally*, ſo that it may have full Relation to the *Horizontal* Thread.

Sixthly, At the Glaſs's Center make a point for the Center upon the *Paſt-board*, and extending a

Thread

Thread from the Center of the *Paſt-board* to the Mark of the *Azimuth* upon the *Horizontal* Thread, draw upon the *Paſt-board* that Line, which the extended Thread Figures out thereupon; afterwards unto the ſame Azimuth upon the *Paſt-board* draw a Meridian Line, and to it an Horizontal Dial; and applying the *Paſt-board* again to its firſt Situation, project the Hours thereon unto the Horizontal Thread, and there make Marks or Knots.

Seventhly, Then project the Meridian (by a Perpendicular Thread, covering in Appearance both the Knot at 12, and the Glaſs) unto the contrary Coaſt to that, wherein the *Pole* is elevated above the Horizon; that is to ſay, in our Northern Climates, you muſt project the Meridian Southward from the Glaſs, becauſe the North *Pole* is elevated: And in the Meridian, elevate your Semicircle, or extend a Thread and Quadrant from the Glaſs Southwards, till the *Plummet* falls upon your Latitude, ſo ſhall it point out upon ſome Object ſet to receive it, the North *Pole* reflected.

Or elſe, if this be not convenient, (becauſe in Windows, which look towards the South, the North Pole will be without the Room, (and ſo the *Axis* above the Glaſs extended towards that *Pole* will be without alſo) you may in ſuch Caſes find out the oppoſite *Pole* to it, that is to ſay, that *Pole* which the former reflected *Axis* being extended through the Glaſs, and below it, would ſign out, and that may be effected in this Manner.

Eighthly,

Eighthly, Project the Meridian Line towards the *Pole* that is elevated, that is with us, towards the North *Pole*; and then (because the North *Pole* is elevated by reflection towards the South, so, by the same Reason, the South *Pole* must be depressed towards the North) by your Semicircle, or String and Quadrant, directed even with the Center of the Glass, express or project your Latitude downwards, (but towards the North) so shall the Semicircle or Thread point out the reflected South *Pole* in the Meridian. Now, whether you will, or can (most conveniently) use the reflected South *Pole* below it, you are to take your Choice, for both the one and the other of them do represent the reflected *Axis* of the World.

Ninthly, By this reflected *Axis,* and the Hour-points signed out upon the Horizontal Thread, you may easily project the reflected Hours, upon any kind of Superficies, one or more, whatever they be, that stand in the Way.

Geometrical Dialling.

C H A P. IX.

How to make a Plain Dial (either South or Horizontal)
that shall give you the Hour of the Day at any Place
or Places assigned, as well as at the Place the Dial is
made for, according to the English Way of reck-
oning.

FIRST, Make a common plain Dial either
South or Horizontal, as you would have
your Dial to be, only in this Case it is best to
place the Hours in a Circular Form,
Plate 11.   as you see it done ; then (besides the
Fig. 1.   two Circles, between which the Hours
are placed) draw so many Concen-
trick Circles as you would have Places in the
Dial, and behind the Stile in each Circle put
the Name of the Place, whose Hour it represents,
then observe what Difference of Longitude the
Places proposed have from *London*, and by al-
lowing 15 Degrees for an Hour, place the Hours
with so much Difference as the Difference of Lon-
gitude

gitude requires, the Shadow shall give the true Hour at any of the Places proposed. But because in this Case a Table of Latitude &c. of Places is necessary, I shall insert the most correct Table of that Kind now extant, and then give an Example of each of the above-mentioned Dials.

A Correct Table of the Latitudes and Difference of Meridians from *London*, of the most eminent Places in the World, mostly corrected by Celestial Observations.

Names of Places.	Latit.		Diff. Merid		
	D.	M.	H.	M.	
A *Capulca* in *Mexico.*	17	30	7	5	W
Agra, the *Mogul*'s Court.	28	30	5	33	E
Aleppo in *Syria.*	37	20	2	15	E
Alexandria in *Egypt.*	31	7	2	12	E
Amsterdam in *Holland.*	49	54	0	9	E
Amiens in *France.*	52	21	0	19	E
Antwerp in *Brabant.*	51	10	0	17	E
Avignon in *France.*	43	51	0	18	E
Babylon in *Chaldea.*	34	30	3	14	E
Barbadoes.	13	30	3	53	W
Barcelona.	41	26	0	10	E
Batavia in *Sumatra.*	6 S	15	6	43	E
Bayon.	43	29	0	6	W
Bengal in *India.*	21	56	6	21	E
Bergen in *Norway.*	61	0	0	32	E
Bononia in *Italy.*	44	30	0	47	E
Boston in *New-England.*	42	25	4	42	W
Brest in *France.*	48	23	0	18	W
Bourdeaux in *France.*	44	50	0	2	W

Cadiz.

Names of Places.	Latit.		Diff. Merid		
	D.	M.	H.	M.	
Cadiz in *Spain.*	36	16	0	30	W
Calais in *France.*	50	57	0	7	E
Camboia in *Italy.*	10	20	7	12	E
Canea in *Crete.*	35	29	1	37	E
Candia.	35	18	1	41	E
Cape *Bona Esperance.*	34 S	15	1	19	E
Cape *Comerin.*	8	0	5	13	E
Cape *Verde.*	14	43	1	9	W
Cayen in the *West-Indies.*	4	56	3	26	W
Cayro.	30	4	2	17	E
Ceylon.	7	50	5	33	E
Cheusan in *China.*	30	0	8	6	E
Cochin in the *East Indies.*	9	25	5	3	E
Conimbra in *Portugal.*	40	30	0	39	W
Constantinople.	41	7	2	7	E
Copenhagen in *Zealand.*	55	40	0	50	E
Corvo.	40	3	2	6	W
Cracow in *Poland.*	50	10	1	18	E
Cusco in *Peru.*	12 S	25	4	55	W
Dantzick in *Poland.*	54	22	1	16	E
Diep in *Normandy.*	49	56	0	4	E
Dublin in *Ireland.*	53	12	0	28	W
Dunkirk in *Flanders.*	51	1	0	9	E
Durazzo in *Dalmatia.*	41	58	1	21	E
Edinburgh in *Scotland.*	55	57	0	12	W
Embden.	53	5	0	30	E
Fero Islands.	28	5	1	13	W
Fei in *Barbary*	33	10	0	24	W
Florentia.	43	41	0	47	E
Frankford.	50	4	0	33	E
Geneva.	46	22	0	26	E
Genoa.	44	27	0	39	E
Ghent in *Flanders.*	51	1	0	15	E

Goa

Names of Places.	Latit. D. M.	Diff. Merid H. M.	
Goa in *India.*	15 30	4 55	E
Goes in *Zealand.*	51 30	0 16	E
Guardaloupa.	14 0	4 9	W
Greenoble.	45 16	0 24	E
Hamburgh.	53 41	0 42	E
Havre-de-grace.	49 30	0 1	E
Heydelburg.	49 20	0 36	E
Hoaignan in *China.*	33 35	7 56	E
Jamaica Port Royal.	17 40	5 4	W
Jerusalem.	31 22	2 28	E
Ingolstad.	48 40	0 46	E
Inspruck.	47 15	0 47	E
Kebrock in *New France.*	47 0	4 40	W
Koningsberg in *Prussia.*	54 43	1 22	E
Leghorn.	43 18	0 51	E
Leige.	50 40	0 24	E
Leipsick.	51 19	0 53	E
Lima in *Peru.*	12 S 20	5 24	W
Lintz in *Austria.*	48 16	1 0	E
Lions in *France.*	45 45	0 20	E
Lisbon in *Portugal.*	38 50	0 42	W
L O N D O N.	51 32	0 0	
Macao in *China.*	22 13	7 44	E
Madagascar.	19 S 29	2 58	E
Madrid in *Spain.*	40 10	0 13	W
Majorca.	39 35	0 10	E
Malacca *Islands.*	2 42	6 40	E
Martinico.	14 44	4 4	W
Marseilles.	43 20	0 22	E
Messina in *Sicily.*	38 21	1 6	E
Mexico.	20 6	6 49	W
Montpellier.	43 36	0 15	E
Moscow.	55 34	2 35	E

Namur.

Names of Places.	Latit.		Diff. Merid		
	D.	M.	H.	M.	
Namur.	50	25	0	10	E
Nangasach in *Japan.*	32	53	8	31	E
Nancy in *Lorrain.*	48	39	0	27	E
Nantz.	47	13	0	6	W
Naples in *Italy.*	41	5	1	3	E
Narbonne.	43	15	0	9	E
Narsinga.	18	15	5	43	E
Nice, *Provence.*	43	38	0	29	E
Ningpo, or *Liampo* in *China.*	29	58	8	1	E
Noremberg.	49	29	0	49	E
Olinda or *Pernambuck.*	7	48	2:	20	W
Oxford.	51	44	0 :	5	W
Ozaca in *Japan.*	35	5	8	53	E
Padua in *Italy.*	45	31	0	45	E
Paris in *France.*	48	50	0 .	9	E
Pekin in *China.*	39	55	7	51	E
Poudicherri.	11	54	5	21	E
Prague in *Bohemia.*	50	40	0	58	E
Ratisbon.	48	59	0	49	E
Reggio in *Italy.*	42	15	0	55	E
Rhodes in *Germany.*	36	42	2	12	E
Rochel.	46	10	0	5	W
Rome.	41	51	0	52	E
Rostock.	54	10	0	51	E
Rotterdam.	51	55	0	17	E
Salamanca in *Spain.*	41	12	0	16	W
Seville.	37	36	0	26	W
Siam in *India.*	14	18	6	43	E
Smyrna.	38	28	1	49	E
Sphahan in *Persia.*	36	14	4	20	E
Stockholm in *Sweden.*	58	50	1	10	E
Syracuse in *Sicily.*	37	4	1	1	E
Tangier.	35	55	0	25	W

Tidore.

Names of Places.	Latit. D. M.		Diff. Merid H. M.		
Tidore.	0	36	6	37	E
Toledo in *Spain.*	39	46	0	14	W
Toulon in *France.*	43	6	0	23	E
Tripoly in *Barbary.*	32	54	0	52	E
Tubing in *Germany.*	48	34	0	37	E
Valencia in *Spain.*	39	30	0	3	E
Venice.	45	18	0	50	E
Vienna.	48	22	1	9	E
Upsal in *Sweden.*	59	0	1	12	E
Uraniburg.	55	54	0	51	E
Utrecht.	52	5	0	20	E
Wittenburg in *Saxony.*	51	53	0	52	E
Wolfembuttle.	52	11	0	44	E
York.	54	0	0	4	W

Note, In the Column of *Latitudes,* where S is placed it is South *Latitude,* and all the reft are North.

I fhall now proceed to apply the foregoing Directions to Practice, and fhall inftance firft in a Horizontal Plain Dial, which fhould be required to give the Hour of the Day at *London, Mexico,* and *Jerufalem.*

Firft, Draw a Horizontal Dial by the Directions given Chap. 3. *Of Geometrical Dialling,* Page 37. which reduced to a Circular Form, will appear as in *Plate* 11. *Fig.* 1. where the middle Circle of Figures reprefents a Dial for the Meridian of

R

London, then within that Circle of Figures draw the Concentrick Circle a b c d for *Mexico*. Also without it draw the Circle e f g h for *Jerusalem*, (or you may draw them both within or both without, but the other is more proper, because one Meridian is East, the other West from *London*) then behind the Stile in the inner Circle write or engrave (*Mexico*) in the middle (*London*) in the outermost (*Jerusalem*) ; then having Recourse to your Table, you find that *Mexico* is West from *London*, 6 Hours 49 Minutes (or which is the same) when it is 12 a Clock or Noon at *Mexico*, it is 49 Minutes paſt 6 Afternoon at *London* ; therefore lay a Scale from Q, the Center of the *Dial*, (which in this Cafe is not confined to the Center of the Circle) to 49 Minutes paſt 6 in the middle Circle for *London*, and there make a Stroak within the inner Circle, which ſhall be the Hour-line of 12 at *Mexico* : Likewiſe lay a Scale from the Center Q to 49 Minutes paſt 5 in the Circle for *London*, and there in the inner Circle for *Mexico*, place the Hour-line of 11 and ſo proceed round the Dial to lay the Scale to 49 Minutes paſt every Hour backwards from 6, you have the Hours from 12 to 11, 10, 9, 8, &c. at *Mexico*, and the ſame Shadow that gives the Hour at *London* in the middle Circle, gives at the ſame Time the true Hour at *Mexico* in the inner Circle.

EXAMPLE.

Suppoſe I go to my Dial in the Forenoon, and find the Shadow of the Stile in the Line Q k, I find it is half an Hour paſt 9 at *London*, and in the inner Circle it is not quite three Quarters of an Hour paſt 2 in the Morning, viz. 41 Minutes

nutes paſt 2, and if you look at 6 in the Morning, it is at *Mexico* but 11 Minutes (*viz.* not a Quarter of an Hour) paſt 11 at Night.

By the ſame Rule you may inſert as many Places in your Dial as it will contain *Concentrick Circles*, and thereby give at one View the Hour at all the moſt remarkable, or remote Places in the World.

The ſame Method is to be obſerved in any other Dial, whether Direct, Declining, Inclining, or Reclining, by placing the Hours at ſo much Difference, as is the Difference of Meridians between *London*, (or any other place that the Dial is made for) and the Place aſſigned; but that the Learner may not be at a Loſs, I have likewiſe drawn a Specimen of a South   *Plate* 11. Dial for *London*, *Jeruſalem*, and *Mexico*,   *Fig.* 2. by which any Perſon may do the like for any other Places, and the Method ſo eaſy and intelligible, that it is not neceſſary to ſpend any more Time in Directions about it.

> *Note*, You may by theſe Tables find the Hour at any Place aſſigned, without having it put upon a Dial, by ſubtracting the Difference of Meridians from the Time at *London*, it the Place be Weſt from *London*, or adding, if it be Eaſt, and thereby having the Time of any Eclipſe, New or Full Moon, &c. at *London*, may know at what Hour and Minute it is at any Place mentioned in the Table.

R 2   CHAP.
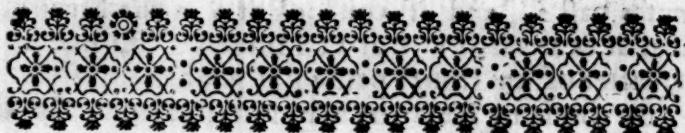
CHAP. X.

Inftrumental Dialling.

SECT. I.

Teaching how to draw the Hour-lines upon any Plain, by the Help of the Lines of Hours, Inclination, &c.

THESE Lines may be infcribed on the Side of any *Dialling Scale, Sector,* or any other Inftrument of Brafs or Wood, and they are commonly known by the Name of the Line of Hours, Inclination, and Latitude, and if you have them upon any plain Scale, you ought to have Chords to feveral Radius's ; but in this Cafe I would rather recommend a Sector, becaufe there you may take Chords Sines or Tangents to what Radius you pleafe.

The firft of thofe Lines is the Line of Hours, commonly known by the Word (Hours) at the Beginning of the Line ; it contains 6 Hours, and is numbred with unequal Divifions from I to VI.

The

The next to that, and close to it, is the Line
of Inclination, known by this (*Incli.*) at the Be-
ginning of it, and is 90 Degrees, divided in the
same Proportion as the 6 Hours are, so that eve-
ry 15 Degrees in one is an Hour in the other, to
shew how many Hours and Minutes of Time an-
swers to any given Number of Degrees and Mi-
nutes of the Æquinoctial.

EXAMPLE.

I would know how many Degrees and Minutes
of the Æquinoctial is contained in an Hour and
a half of Time. Look against an Hour and a
half on the Line of Hours, and under that on
the Line of Inclination you find 22 deg. 30 min.
and so much is contained in an Hour and a half
of Time.

The next is the Line of Latitude, marked
(Lat.) at the Beginning.

Some have two Lines more, one marked (G
Pol.) and the other (L Pol.) but by a Sector those
Lines may be more commodiously supplied from
the Tangent; but I shall shew the Use of both,
and to avoid Prolixity, I shall fall directly upon
Examples of the Use of these Lines in making
Dials upon any Plain.

R 3 SECT.

SECTION II.

How to draw the Hour-lines on a Horizontal Dial, for Latitude 51 *deg.* 32 *min.*

FIRST, Draw the Line E W for the fix a Clock Line, and at right Angles thereto draw the Line N S for the 12 a Clock Line to biffect the former, where you intend to have the Center of your Dial as at A.

Then fixing one Foot of your Compasses in the Beginning of your Line of Latitude, extend the other to 51 deg. 32 min. the Latitude of the Place, and set that Extent from A to E, and from A to W; then take in your Compasses the whole Scale of Hours, and with that Extent and one Foot in E or W, with the other Foot crofs the Meridian, or 12 a Clock Line in S, and draw the Lines Q S and W S.

Then take in your Compasses the Diftance upon the Line of Hours from the Beginning of the Line to I, and fet that Diftance from S to 1 and 11, and alfo from E to 5, and from W to 7; take alfo the Diftance from the Beginning of the Line to II on the Scale of Hours, and fet from S to 2 and 10, and alfo from W to 8, and E to 4: Alfo the Diftance from the Beginning of the Line to I I I, and fet from S to 9 and 3, which will alfo be equal to the Diftance W 9, or E 3. Now Lines drawn from the Center A through thefe Figures, 7, 8, 9, &c. to the Limb of the Dial (which may be Square or Round in

what

what Form you pleafe) gives the true Hour-
lines of that Dial only for the Hours before 6 in
the Morning, *viz.* 4 and 5, and likewife 7 and 8
at Night, they muft be continued through the
Center from their oppofite Hours, and then are
your Hour-lines finifhed; and for the Stile, it
muft be a Plate of Brafs, or the like, to make an
Angle of 51 32 (the Latitude of the Place) with
the Plain, the Angular Point being fixed juft at
the Center A, and the Stile ftanding upon the
Meridian-line at right Angles with the Plain of
the Dial, and then is your Dial finifhed.

SECT. III.

How to draw Hour-lines upon a direct South-Dial.

THE fame Directions, that ferve for a *Hori-*
zontal Dial, may with a little Alteration
ferve for drawing the Hour-lines upon a South
Dial, for if inftead of taking the Latitude of the
Place off from the Scale of Latitudes, you take
the Complement, proceed in all Refpects as be-
fore, only number the Hours the contrary Way,
it will produce a South Dial. The Reafon is,
becaufe as the North Pole is elevated above the
Plain of the Horizontal Dial, equal to the Lati-
tude of the Place, fo the South Pole is elevated
above the Plain of the South Dial, equal to the
Complement of the Latitude of the Place. There-
fore

fore if you would make a South Dial for Latitude 51 deg. 32 min. take 38 deg. 28 min. the Complement of the said Latitude, (or if you work for any other Latitude, take always the Complement of the Latitude you work for) out of your Scale of Latitudes, and work in all Respects as you did before, only accounting the Meridian-line for the Hour of 12, number the Figures the contrary Way, *viz.* to the right Hand of the Meridian, as Practice and even Reason it self will inform you ; and as in the other the Stile made an Angle with the Plain of the Dial equal to the Latitude of the Place, so the Stile in this must make an Angle with the Plain of the Dial equal to the Complement of the Latitude, and both stand at right Angles with, or perpendicular to the Plain.

SECTION IV.

Of a direct North Dial.

A North Dial is the same in all Respects with a South Dial, only in a North Dial the Stile points upwards towards the North Pole, because the North Pole is elevated above the *Plain* of that Dial equal to the Complement of Latitude ; for it is an universal Rule in all *Dials* that shew the Hour of the Day by a strait lined Stile, to have that strait side of the Stile whose Shadow gives the Hour, to lie parallel to the Axis of the World, and

and to point directly to that Pole which is elevated above the *Plain* of the *Dial*: And the Divisions for the Hour-lines are the same, as in a South *Dial*, if they were to be inserted; but as it would be superfluous to describe Hours which could never be shew'd by the Sun, it is proper to omit the Hours about Midnight, *viz.* 9, 10, 11, 12, 1, 2, 3, at which Hours the Sun is under the *Horizon* even at the longest Day, in the Latitude of *London*, but if you work for a more Northerly Latitude, you must put on more Hours; as suppose you should make a North *Dial* for Latitude 64 deg. 00 min. the longest Day there is 20 Hours 24 Minutes, its Complement to 24 Hours is 3 Hours 36 Minutes, the Length of the Night at that time; half the length of the Night is always the time of the Sun's Rising, which in the forementioned Latitude 64 deg. is 1 Hour 48 min. for the time of Sun's Rising in the Morning, and half of 20 Hours 24 min. *viz.* 10 Hours, 12 min. is the Time of Sun's Setting at the longest Day in that Latitude: But that the Artist need not be put to the Trouble of Calculation, I have inserted a Table, which shews the Length of the longest Day in all Latitudes, either North or South, *viz.* from *Pole* to *Pole*; and although the same Table extended from the Æquinoctial to the Polar Circles, might have served in common Uses, yet for the Satisfaction of the Curious, I have inserted the whole, as follows.

A Table

A Table shewing the Length of the longest Artificial Day, in all Places from the Æquinoctial to the Poles of the World.

Height of Pole	Longest day H.	M.	Height of Pole	Longest Day H.	M.	Height of Pole	Longest Day D.	H.	M.
0	12	0	47	15	42	68	42	1	16
6	12	20	48	15	52	69	54	16	25
12	12	42	49	16	0	70	64	13	46
16	12	58	50	16	10	71	74	0	0
20	13	12	51	16	20	72	82	6	36
24	13	30	52	16	30	73	89	4	58
27	13	42	53	16	42	74	96	17	0
30	13	56	54	16	54	75	104	1	4
32	14	6	55	17	8	76	110	7	27
34	14	16	56	17	22	77	116	14	22
35	14	22	57	17	36	78	122	17	6
36	14	28	58	17	52	79	127	9	55
37	14	34	59	18	10	80	134	4	58
38	14	38	60	18	30	81	139	31	36
39	14	44	61	18	54	82	145	6	43
40	14	52	62	19	20	83	152	2	6
41	14	58	63	19	50	84	156	3	3
42	15	4	64	20	24	85	161	5	23
43	15	12	65	21	10	86	166	11	23
44	15	18	66	22	18	87	171	21	47
45	15	26	66½	24	0	88	176	5	29
46	15	34	67	24 Days		89	181	21	58
						90	187	6	39

The Use of this Table is very easy, for in the 4 first Columns you have the length of the longest

eſt Day in any given Latitude in Hours and Minutes, and in the two laſt Columns you have the length of the longeſt Day in Days, Hours, and Minutes, the Sun in theſe Latitudes remaining above the *Horizon* during ſo many Days, while he is near his greateſt *Declination*, of the ſame *Denomination* with the Latitude of the Place, whether *South* or *North*, and when the Declination is contrary, the longeſt Night is the ſame Length.

E X A M P L E.

In Latitude 60 deg. North, the *Longeſt Day* is 18 Hours 30 Minutes, which happens when the Sun enters *Cancer*, and hath 23 deg. 30 min. *North Declination*; but in 60 deg. *South*, the Day is the ſame length, when the Sun enters *Capricorn*, and ſo in the reſt, but beyond *Latitude* 66 deg. 30 min. the Sun continues above the *Horizon* ſeveral Days, half of which is before the *Tropick*, and the other half after it.

E X A M P L E.

I deſire to know the *Longeſt Day* in *Latitude* 71 deg. 00 min. and I find it in the Table 74 Days, *viz.* 37 Days before the *Tropick*, and as many after it, which is from the 4th of *May* to the 17th of *July*, in all which Time the Sun never ſets in that *Latitude.*

By this Table the Artiſts may know by Inſpection how many Hours are proper to be put upon any Erect, Direct, North Dial, or any *Horizontal Dial*, in any Latitude whatſoever.

SECT.

SECTION. V.

Of South or North Reclining Dials.

IN a Direct North or South Reclining Dial, there need be no Directions given, but what are already laid down, for all such *Dials* are *South Dials*, or *Horizontal Dials*, in some other Latitude; for a *Horizontal Dial* in Latitude 51. 32. or any other Latitude, is only a *South Dial* Reclining 90 deg. for in an Erect *South Dial*, the *South Pole* is elevated above the *Plain* of the *Dial*. equal to the Complement of the Latitude; therefore if a *North Dial* in *South Latitude*, or a *South Dial* in *North Latitude*, recline equal to the Complement of the Latitude, the Plain of the *Dial* becomes parallel to the Axis of the World, and Stile of the *Dial*, and then that becomes a *Horizontal Dial* under the Æquinoctial, and hence these general Rules may be deduced.

1. If a *South Dial* recline less than the Complement of Latitude, it becomes a *Vertical Dial* for a Latitude, so much more than the given Latitude as the Reclination is. Or more plain, Add the Reclination to the Latitude, the Sum is the Latitude, where that is an Erect or Vertical Dial.

EXAMPLE.

Suppose I would make a *South Dial* for Latitude 51. 32. North Reclining 32 deg. Add 22 deg.

deg. to 51 deg. 32 min. the Sum is 73 deg. 32 min. therefore make an erect direct *South Dial*, for Latitude 73 deg. 32 min. North, the ſame ſhall be a direct South *Dial* reclining 22 deg. for Latitude 51 32, and the Rules for making it are the ſame in all Reſpects.

2. If the Reclination be equal to the Complement of Latitude, it becomes a *Horizontal Dial* under the Æquinoctial, for Reaſons before given.———— Therefore,

3. If a South *Dial* in North Latitude (or a North *Dial* in South Latitude) recline more than the Complement of Latitude, it will be a *Horizontal Dial* for ſuch a Latitude, as the Reclination is more than the Complement of Latitude : Or thus, ſubſtract the Complement of Latitude from the Reclination, the Remainder is a Latitude, for which if you make a *Horizontal Dial*, it ſhall alſo be the *Dial* for the Latitude and Reclination propoſed.

E X A M P L E.

I deſire to make a *Dial* for Latitude 60 deg. North, to recline 40 deg.

Subtract 30 the Complement of Latitude from 40 the Reclination, the Remainder is 10 ; therefore a *Horizontal Dial* for Latitude 10 North, is the ſame in all Reſpects as a South *Dial* reclining 40 deg. for Latitude 60 deg. North.

For it is plain, that if the *Dial* had reclined but 30 deg. the Plain had been parallel to the Axis of the World, but reclining 10 Degrees more, elevates the contrary Pole 10 Degrees, and becomes a *Horizontal Dial* for that Latitude.

Upon the ſame Ground we may deduce Rules for Incliners, for if we conſider, that the Stile of

all *Dials* fhould lie parallel to the *Axis* of the
World, and confider how much the Angle, that
the Stile makes with the *Plain* of the *Dial*, is aug-
mented or diminifhed by the Inclination of the
Plain, it gives you the Latitude for which a
Vertical Dial being made, it will be a North or
South *Dial* with the given Inclination, and for
the given Latitude, for which I think one Ex-
ample fufficient.

E X A M P L E.

I would make a South *Dial* for Latitude 51
32 North, to incline 10 deg.

It is evident, that this *Dial* that inclines 10
deg. would be Vertical, or perpendicular to the
Horizon in a Latitude 10 degrees lefs, therefore
for a South Inclining *Dial* in North Latitude,
or North in South Latitude,

1. If the Latitude be more than the Inclina-
tion, fubtraƐ the Inclination from the Latitude,
the Remainder is the *Latitude* where the fame
Dial is Vertical.

2. If the Inclination be equal to the *Latitude*,
it is an *Æquinoclial Dial* under the *Æquinoclial.*

3. If the Inclination be more than the Lati-
tude, fubtraƐ the Latitude from the Inclination,
the Remainder is the Latitude, where the *Dial* is
Vertical, but of a contrary Denomination, *viz.*
if the *Dial* is to be made for North *Latitude* it is
Vertical, in South *Latitude, & contra.*

S E C T.

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SECT. VI.

How to draw Hour-lines upon a Direct Eaft or Weft Dial.

I Shall begin with an Example of an Eaft *Dial* for *Latitude* 51, 32 North.

Take in your Compaffes the Chord of 60, and with one Foot in C, draw Plate 11. the Arch A B, and fet off the Com- Fig. 2. plement of *Latitude* from A to B, and through B draw the lines C B E, then fome where towards the upper end of the line C E as at R, draw G R F perpendicular to C E for the Subftile and Hour-line of 6, and draw I H parallel to E C, and at any competent Diftance from it, then from one of the lines marked (*Pol.*) on your Scale take the Diftance from the Beginning of your Scale to I, and fet that Extent from R to 5, and from R to 7; then take the Diftance from the End of your Scale to II, and fet from R to 4, and to 8, fet alfo the Diftance from the Beginning of the Scale to III, and fet from R to 9, and fo proceed to find the Hours of 10 and 11 by the Figures I I I I, and V, upon the Scale, and draw the lines 4 4. 5 5. 7 7, *&c.* parallel to 6 6. thefe fhall be the Hour-lines required.

The Diftance from the Beginning of the Scale to III. is the Height of the Stile, and muft ftand upon the Hour-line of 6, and perpendicular to the Plain of the *Dial*, and then is your Dial finifhed.

The making of a Weft *Dial* is all the fame, only as the Eaft *Dial* is elevated towards the left Hand equal to the Complement of Latitude, the Weft *Dial* is elevated towards the right Hand, and inftead of 4 5 6 7 8 9 10 11, in the Eaft *Dial*, you muft upon the Weft *Dial* put on the Figures 1 2 3 4 5 6 7 8, becaufe the Afternoon Hours are defcribed upon the Weft *Dial*, as the Forenoon Hours are upon the Eaft *Dial*.

But in working by thofe Lines you are confined to a certain Bignefs for your Dial (except you inlarge it afterwards) and therefore I hold it much better in this Cafe, to make ufe of the Tangents upon the Sector; and having firft confidered how large you intend your Dial fhall be, and confequently determined the Height of your Stile, take the Height of the Stile in your Compaffes, and open the Sector, till the aforefaid Extent will juft reach from the Tangent of 45 on one fide of the Sector, to the fame Tangent on the other fide, and keeping the Sector at that Opening, take in your Compaffes the Tangent of 15 deg. and fet from R to 5 and 7; take alfo the Tangent of 30, and fet from *Plate* 11.   R to 4 and 8; the Tangent of 45, or *Fig.* 2.   Radius, which is alfo the Height of the Stile, is the Hour-line of 9; and as every 15 deg. of the Æquinoctial make an Hour of Time, fo proceed to take the Tangent of 60 and 75, they give the Hour Marks for 10 and 11, from which drawing Lines crofs the Dial parallel to 6 6, as before directed, gives the Hour-lines required.

Note. When you would take a Tangent lefs than 45, you muft make the 45 at the End of the

the Sector Radius; but when you would take a Tangent above 45, you muſt make that 45 Radius, which is at the Beginning of the remaining Tangents, (which is alſo marked T) and proceed as before.

S E C T. VII.

How to deſcribe Hour-lines upon direct Eaſt or Weſt Reclining Plains.

I Shall not trouble my ſelf to give any Directions for drawing Hour-lines upon Eaſt or Weſt Reclining *Dials*, conſidered as ſuch; for as in *Sect.* 5. you have Directions how to find in what *Latitude* any North or South Recliner becomes a *Vertical Dial* or an *Horizontal Dial*, and it is alſo ſhew'd in *Page* 125, how to reduce any Eaſt or Weſt reclining Plain to an erect declining Plain in another *Latitude*, or in what *Latitude* the given Plain ſhall be an erect Plain, and how much it declines; it will therefore be ſufficient to ſhew how to draw Hour-lines upon all erect declining Plains, becauſe in them all Eaſt and Weſt Recliners are included.

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SECT. VIII.

To draw Hour-lines upon a North or South declining Plain.

I Shall inſtance in a South Erect Plain decli-
ning Weſtward 24 deg. 20 min. for the La-
titude of *London*, 51 deg. 32 min. North. (See
Chap. 7, Page 46 and 47.)

Here are two Things given, and 3 required
before you can proceed.

Given { The Latitude   51 32 }
       { The Declination 24 20 }

Required { The Subſtile's Diſtance from the
         { Meridian.
         { The Height of the Stile above the
         { Plain.
         { The Inclination of Meridians.

1. *For the Subſtile's Diſtance from the Meridian.*

As Radius ————————————————10.000000
To the Sine of the Plain's Decli-⎫
nation 24 20   ⎬ 9.614944
So Tang. Comp. of Latitude 38 28   9.900086
                    ————————————
To Tang. of Subſtile's Diſtance ⎫
from the Meridian   18 9 ⎬ 12.515030

2 *For*

2. *For the Height of the Pole or Stile above the Plain.*

As Radius——————————— 10.000000
  To Sine Complement of Lati- } 9.793831
  tude 38 deg. 28 min.   }
So Sine Complement of Declina- } 9.959596
  tion 65 deg. 40 min.   }

To Sine of the Stile's Height a- } 19.753427
  bove the Plain 34 deg. 33 m. }

3. *For the Inclination of Meridians.*

As Radius——————————— 10.000000
  To Co-Tangent of Declination } 10.344652
  65 deg. 40 min.   }
So is the Sine of Lat. 51 deg. 32 min. 9.893745

To the Co-Tang. of the Incli- } 10.238397
  tion of Meridians 30 d. 00 m. }

Or if you would confine your ſelf to Inſtru-
mental Operations, the ſame may be performed
upon the *Gunter's* Scale thus :.

1. *For the Subſtile's Diſtance from the Meridian.*

The Extent from Radius to the Sine of the
Plain's Declination 24. 20. will reach from the
Tangent Complement of Latitude 38 28 to
the Tangent of the Subſtile's Diſtance from
the Meridian 18 9.

2 *For*

2. For the Height of the Stile.

Extend from Radius to the Sine Complement of Latitude 38 28, the ſame Extent will reach from the Sine Complement of Declination 65 40, to the Sine of the Stile's Height, 34 33.

3. For the Inclination of the Meridian.

The Extent from Radius to the Sine of Latitude 51 32, will reach from the Co-Tangent of Declination 65 40, to the Co-Tangent of the Inclination of Meridians 30 00.

The Requiſites thus found, draw the *Horizontal-line* H O, and in ſome conveni- *Plate* 11. ent part of that Line, as in C, fix the *Fig.* 3. Center of your *Dial,* and from thence draw C 12 perpendicular to H O, then with 60 deg. of the Chord, and one Foot in C, make the Arch *y z,* upon which ſet off 18 deg. 9 min. the Subſtile's Diſtance from the Meridian from *y to x,* and draw C *x* F for the Subſtile.

Note, The Subſtile muſt be on the right Hand of the Meridian, becauſe the Plain declines to the Weſtward, and ſhould have been on the left Hand, if it had declined Eaſtward.

Then through C, and at right Angles with the Subſtile, draw the Line A B, and from the Scale of Latitudes take 34 deg. 33 min. (the Height of the Stile) and ſet from C to A, and from C to B. Take in your Compaſſes the whole Scale of 6 Hours, and with one Foot in A or B, turn the other about, till it touch the Subſtile, as in F, and draw the Lines A F and B F.

Find

Find the Inclination of Meridians (which in this Example is 30 deg.) in the Scale of Inclinations, and against that in the Line of Hours you find 2. Therefore take 2 Hours in your Scale, and set from F to 12, and from B to 6. Take also 1 Hour off the Scale of Hours, and set from F to 1, and from B to 7. In the same manner take 3 Hours off the Scale, and set from F to 11, and from B to 5. Likewise set 4 Hours off the Scale from F to 10, and from B to 4. Also set 5 Hours off the Scale, from F to 9, and from B to 3, and for the 2 a Clock Line it happens to fall just in the *Substile*, because the Inclination of the Meridian is just 30 deg. which at 15 deg. to an Hour, makes two Hours : And for the Hour of 8 in the Morning, continue the Hour-line of 8, which falls above the *Horizontal-line* on the right Hand, quite thro' the Center to the Edge of the *Dial*, and it shall be the Hour-line of 8 in the Morning, and for the rest, draw Lines from the Center C through the Marks 1 2 3 4 5, *&c.* to the Edge of the *Dial*, they shall be true Hour-lines for that *Dial*.

The *Stile* must stand upon the *Substile*, and perpendicular to the Plain of the *Dial*, the back Part of the Stile that gives the Hour by the *Shadow*, making an Angle of 34 deg. 33 min. with the Plain of the *Dial* equal to the Height of the *Stile* before found.

Note, The Inclination of the Meridian being just 30 deg. the *Substile* falls just upon the *Hour-line* of 2, but if it had been any other odd Number, as suppose 35 deg. this found in the Line of Inclination, there is against it in the Line of Hours, 2 Hours 20-Minutes, then you must have set off from the Line of Latitudes 2 Hours 20 Minutes, from F to 12, and from B to 6, and o Hours

0 Hours 20 min. from F to 2, and from B to 8, and so in any other Case.

In drawing this *Dial*, you have likewise made 3 more, for which to avoid Repetitions, I shall refer you to Page 50 in the 7th Chapter, and to the Figures of them in Plate 3. Fig. 4.

SECT. IX.

How to draw Hour-lines upon a Dial that declines so far, that the former Directions will not be sufficient.

I Desire to draw the Hour-lines upon an erect Plain, declining from the South Eastward, 80 deg. Lat. 51 32.

(See the same Chap. 8. Page 51.)

You are already taught in the last Section, how to find the Requisites, which are by those Rules found to be as followeth.

	deg.	min.
Substile's Distance from the Meridian	38	2
Height of the Stile	6	12
Inclination of Meridians.	82	9

Draw the Line H I, and with the Chord of 60, and one Foot in H, describe the Arch M N, and from M set off the *Plate* 11. Substile and Stile to make their respective Angles with the Line H I, *viz.* the Substile to make an Angle of 38 deg. 2 min. and the Stile to make with the Substile an Angle of 6 deg. 12 min. or with the Line H I an Angle of 44 deg. 14 min. and draw H C B for the *Substile*, and H K L to represent the *Stile*.

Then

Then in any convenient Place towards the lower End of the Subſtile, as at B, draw a Line at right Angles with the Subſtile, as the Line F B D, then with one Foot of your Com-paſſes at the Beginning of your longer Polar Scale, extend the other to the Hour of 3, ſet that Extent from B to D, and through D draw the Line D E parallel to the Stile H K L, then is D E the augmented *Stile.* Then with one Foot of your Compaſſes in the beginning of your leſſer Polar *Scale*, extend the other to 3 Hours, and with that Extent place one Foot in the *Subſtile* B C H, carry it along the *Subſtile*, till the other Foot juſt touch the Line D E, which will be when the other Foot is in C, then make a Mark, and through C draw a Line parallel to the Line F B D, as the Line E C G, then find the Inclination 82 deg. 9 min. in the *Scale* of In-clination, and againſt it in the *Scale* of Hours you have 5 Hours 29 Minutes, which ſhews that the *Subſtile* falls between the Hours of 6 and 7 in the Morning (the Declination being Eaſter-ly) but had been between 5 and 6 in the Af-ternoon if it had been Weſterly.

Now if the Hour-line of 12 be 5 Hours 29 Minutes from the *Subſtile*, the Hour-line of 11 muſt be 4 Hours 29 Minutes from it, &c. and the Hour-line of 7 is 0 Hours 29 Minutes from it, and if ſo, the Hour-line of 6 muſt be 0 Hours 31 Minutes on the contrary Side, be-cauſe 29 Minutes and 31 Minutes make juſt an Hour, &c. and all the other Diſtances, as in the following Table.

From

From B towards F.			From B towards D		
H.	M.	Hour on the Plain.	H.	M.	Hour on the Plain.
0	29	B 7	0	31	B 6
1	29	B 8	1	31	B 5
2	29	B 9	2	31	B 4
3	29	B 10	3	31	B 3
4	29	B 11	4	31	B 2

The Use of this Table is very easily under-
stood, for, take (according to the Table) 0
Hours 29 Minutes from the greater Polar *Scale*,
and set from B towards F, it shall fall at the
first * in the Line D B F. Take likewise 1
Hour 29 Minutes, 2 Hours 29 Minutes, 3 Hours
29 Minutes, &c. from the said greater Polar
Scale, and set them upon the Line D B F, from
B towards F, to the several Points * * * &c.
and the contrary Way, set the Distances 0
Hours 31 Minutes; 1 Hour 31 Minutes, &c.
upwards from B upon the same Line, to the
Points * * * &c. it finds the Points for the
Hours of 6, 5, 4, &c. do the same by the les-
ser Polar *Scale* from the same Table, and find
the Marks * * * in the Line E C G ; then
laying a Ruler over the two Marks next below
the *Substile*, a Line ruled thereby shall be the
Hour-line of 7, and by the two next Marks, a
Line ruled shall be the Hour-line of 8 ; and so
in all the rest, as you see in the Figure.

The

The *Stile* in this, as in all others, must stand directly over the *Substile*, and must be a Plate of Iron or Brass, and in the Form of the Figure B C E D.

In the making of this Dial, you have also made a *South Dial* declining West 80 deg. only for the Hours 6, 7, 8, 9, 10, 11, you must put 1, 2, 3, 4, 5, 6, &c. You have also made a North Dial declining East 80 deg. and a North Dial declining West 80 deg. with only inverting the *Stiles* and *Figures*, as you are taught Page 50, in the 7th Chapter before-mentioned, and the Figure (*Plate* 3. *Fig.* 4,) may sufficiently illustrate this also.

SECT. X.

Of Declining Reclining Plains, and how the Hour-lines may be described on them.

ALthough we have elsewhere in this Book laid down several Methods for effecting this, yet in order to reduce the whole into as narrow a Compass as possible, we shall in this Section shew how those Declining Reclining Plains may be reduced to new Latitudes, and new Declinations, and be made by the Directions given in Sect. 8. by the Lines on the Scale.

EXAMPLE.

It is required to make a South Plain for Latitude 51 deg. 32 min. North, to decline from the South-westward 24 deg. 20 min. and to recline from the Zenith 54 deg.

T

The

The Canon to find the new Latitude is.

As Radius———————————— 10.000000
   To Sine Compl. Declin. 24 20   9.959596
So Tang. Compl. of Reclin. 54 0   9.861261

   To Tangent 33 30 ——————— 9.820857
In South Reclining Plains, as our Example is,
the Difference between the Tangent last found
(which here is 33 30) and the Latitude of the
Place is the Complement of the new Latitude
sought.

                        d.   min.
Latitude of the Place   51   32
Tangent found   33   30

      Remains ————— 18   2   whose
Complement 71 58 is the new Latitude sought.
Only observe, that if the Tangent be more than
the Latitude, the same Pole is elevated ; if less,
as here it is, the contrary Pole is elevated, and
consequently, if they be equal, neither Pole is
elevated, but it is an Æquinoctial Plain.
       But for North Recliners,
   If the Tangent last found be equal to the Com-
plement of Latitude, the Plain is a Polar decli-
ning Plain ; but if greater or lesser than the Com-
plement of Latitude, the Difference is the new
Latitude.

      The Canon to find the New Declination.

As Radius———————————— 10.000000
   To Sine Compl. Reclin. 54 0   9.769219
So Sine of Declination —— 24 20   9.614944

   To Sine of 14 d. 1 min.   19.384163
                             This

This 14. deg. 1 min. is the new Declination, therefore if it be required to make a Dial for Latitude 51 deg. 32 min. to decline from the South-weſtward 24 deg. 20 min. and to recline from the Zenith 54 deg. 00 min. you may proceed (by the Directions given, Chap. 7. Page 46. of *Geometrical Dialling,* or Part 3. Sect. 3. and 8. in Page 129, and Page 141,) to make an upright Dial for Latitude 71 58 (the new Latitude) and to decline 14 deg. 1 min. from the South, (according to the new Declination found) that Dial ſhall ſerve for the Dial required.

Note, The Declination thus found, is always leſs than the old Declination was, but is always the ſame way, *viz.* Eaſt or Weſt, as the old Declination was.

But to apply this new Dial to the Plain propoſed, you muſt not place the Meridian or Hourline of 12 perpendicular to the Horizon, but it muſt make a certain Angle with the *Horizontalline* of the Reclining Plain, which we call the Meridian Aſcenſion or Deſcenſion, which is found thus :

As Radius ——————————————10.000000

| To Sine of Reclination | 54 | 0 | 9.907958 |
| So Tang. of old Declinat. | 24 | 20 | 9.655348 |

To Tang. of 20 deg. 6 min. 19.563306 whoſe Complement 69 deg. 54 min. is the Angle that the Meridian makes with the Horizon.

Having thus obtained the Meridian, Aſcenſion or Deſcenſion, *viz.* the Angle that the Meridian makes with the Horizon, your next Work is to find the Poſition of the Meridian-line and Subſtile, for which ſee the three following Pages.

T 2

In

That End of the Horizontal Line, which lies contrary to the Coast of the Plain's Declination.

above

below

Less than Æquinoctial, the Meridian must be drawn.

North Incliners.

In South Recliners.

That End of the Horizontal Line, which lies the same Way with the Coast of the Plain's Declination.

below

above

More than Æquinoctial, the Meridian must be drawn.

That End of the Horizontal Line, that looks the same Way with the Coast of the Plain's Declination. And this Meridian thus drawn in North Recliners, represents 12 at Night.

above

below

Less than a Polar the Meridian must be drawn.

North Recliners.

In South Incliners.

Equal to a Polar the Meridian muſt be drawn below the Horizontal Line at that End which is contrary to the Coaſt of Declination, and the Six of Clock Hour-line is always the Subſtile.

More than a Polar the Meridian muſt be drawn.

Upon all Plains, whereon { below { above

And from that end of the Horizontal Line, which lies contrary to the Coaſt of the Plains Declination—And in South Incliners its is only ſerviceable to help to draw the reſt of the Dial.

North Re-cliners.
In
South In-cliners.

All the Rules, Praxes, and Examples given in this Order, do ſuppoſe the work to be in the Nor-thern Hemiſphere: ſo that would it therefore is should be in a Southern Hemiſphere, there Praxes will ſerve there alſo, by only changing the Words North and South one into the other, viz. for South-read North, and for North read South, and ſo Northern for Southern, and the

T 3

r. To know which Way the Subftilar Line of any Dial muft ftand from the Vertical Line of the fame Plain.   And

2. How to order your Work in the Southern Hemifphere.

For the Firft.

Upon all Plains whereon the

North Pole   South Pole

is elevated, the Subftilar muft lie from the

Upper End   Lower End

of the Vertical Line towards the full

North   South

For the Second.

All the Rules, Precepts and Examples given in this Cafe, do fuppofe you to be in the Northern Hemifphere of the World ; therefore if you fhould be in a Southern Hemifphere, thefe Precepts will ferve there alfo, by only changing the Words North and South one into the other, as for South read North, and for North read South, and fo Northern for Southern, and the contrary.

For

For placing your Dial, draw an Horizontal Line upon your Plain, and ſet off ſo many Degrees by the Help of your Line of Chords, as the Diſtance of the Meridian and Horizon is found to be, and to the right Coaſt ; there draw your Meridian Line, then apply your Paper Draught to your Plain, laying the Meridian-line of your Paper Draught exactly upon the Meridian-line (now found) upon your Plain, and take Care that the Subſtile lie according to the Directions now given, and that the Stile do always point towards the Pole, that is elevated above your Plain, and then by pricking through your Paper, or any other convenient Means, you may transfer the Hour-lines, &c. to your new Plain, and drawing the Hour-lines you have the Dial required.

As for Eaſt or Weſt Recliners or Incliners, the reducing them to erect Decliners in other Latitudes, and the Meridian-line in theſe Co-inciding with the Horizontal-line, and having no Elevation or Depreſſion, there is no Difficulty in placing them, when rightly made.

Alſo North and South Incliners or Recliners, being erect direct Dials in other Latitudes, are to be made as ſuch, and then placed in the Latitude propoſed, with the given Reclination or Inclination, &c. which is eaſily intelligible to every Capacity.

SECT.

SECTION XI.

How to make a Polar Dial.

IN making a Polar Plain, you have no more to do but draw a Circle, and divide it into 24 equal Parts for the Hours, and draw Lines from the Center of the Dial through these Divisions to the Edge of the *Dial*, which may be round, square, or what Form you please, and placing 12 on that side towards the elevated Pole, put 11, 10, 9, &c. of the Forenoon Hours, and 1, 2, 3, &c. of the Afternoon Hours so far as you have occasion, will be the true Hour-lines of a *Polar Dial.*

Example of a Polar Dial for Latitude 51 *deg.* 32 *min.*

Let the Square A B C D be your Plain, bissect
A B in *e,* and C D in *f,* and draw
Plate 11. *e f.* Also bissect B C in *g,* and A D
Fig. 5. in *h,* an draw *g h* perpendicular to
e f, to cut each other in Q ; then,
upon Q as a Center, describe the Circle *r s u,*
and beginning at *r,* divide the Quadrant *r s* into
6 equal parts, and each of the Quadrants in the
Points * * *, &c. Lines drawn from the Center Q through these Marks, are the true Hour-lines in such a *Dial.*

Note. A *Polar Dial* to be placed under the *Pole,* ought to have all the 24 Hours upon it ; but because a *Polar Dial* to be placed in any other Latitude is only a North *Dial* reclining equal to the Latitude of the Place, and because in Latitude

51 deg.

51 deg. 32 min. the Sun never riseth till after 3 in the Morning, and always setteth before 9 at Night, it will be sufficient in this to insert the Hours from 4 in the Morning to 8 in the Evening.

The Stile is only a Pin of Brass, Iron, or the like, fixed in the Center Q, and placed perpendicular to the Plain of the *Dial.*

SECT. XII.

Of an Æquinoctial Dial. Pl. 11, Fig. 6.

AN Æquinoctial *Dial* is a South Recliner in North Latitude, or a North Recliner in South Latitude, equal to the Complement of Latitude, and is most properly done upon an Oblong Plain, thus;

At a convenient Distance from the Edge of your Plain, draw the Line B C, and parallel thereto near the other Edge draw the Line D E, and through the Middle of these draw F G perpendicular to them, for the Hour-line of 12.

Then upon either of the *Polar Scales* marked (*Pol.*) take the Distance from the Beginning of the Scale to I, and set that Extent from F, and also from G, both ways to 11 and 1, on the Lines B C and D E. Again, Extend your Compasses from the Beginning of your *Scale* to II, and set that from F and G, both ways upon the Lines B C and DE to 10 and 2; take also the Distance from the Beginning of the Scale to III, and set from F and G to 9 and 3, and in like manner take the Distance from the Beginning of the Scale to IIII, and set from F and G to

G to 4 and 8. And laftly, take the Diftance from the Beginning of the Scale to V, and fet from F and G to 7 and 5, (the Hour of 6 can never come into an Æquinoctial Plain) then draw the Lines 7 7, 8 8, 9 9, &c. thefe are the true Hour-lines on that *Plain.*

The Stile may be a thin Plate of Brafs, Iron, &c. and muft ftand upon the *Hour-line* of 12, perpendicular to the *Plain* of the Dial, its Top or Edge that cafts the Shadow muft be parallel to the Hour-line of 12, and it's Height muft be the Diftance between the *Hour-lines* of 12 and 3, and then is your Dial finifhed.

Or the fame may be performed by the Help of a *Sector,* if you make the intended Height of your *Stile* Radius, and at that Opening fet the Tangent of 15, 30, 45, 60, and 75, from the 12 a Clock Line both ways to 11 and 1, to 10 and 2, to 9 and 3, to 8 and 4, and to 7 and 5, as you were taught in making an Eaft Dial, to fet the fame from the 6 a Clock *Line* to the Hours of 7 and 5, 8 and 4, &c. which is fo plain, that I need not enlarge upon it.

Note, *In this and all other Dials that fhew the Hour by a Stile or Gnomon, you muft allow for the Thicknefs of the Stile, imagining the Dial to be cut in two in the Subftile, and the Parts drawn fo far afunder as the Thicknefs of the Stile ; for as* it is impoffible to make a *Stile* without fome *Subftance* in Thicknefs, it will follow that the *Dial* would be too flow, when the Weft-fide gives the fhadow, and too fwift when the Eaft-fide gives it, if the *Subftile* do not poffefs a fpace equal to the Thicknefs of the Stile, to contain all the fhadow of the *Stile,* when the *Sun* is juft perpendicular to it.

CHAP.

Fig. 1.

Mexico
London
Jerusalem
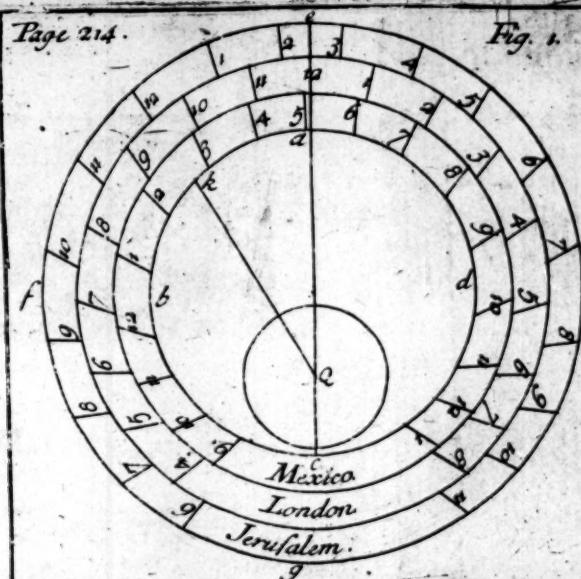
Jerusalem
London
Mexico

Plate XI

Fig. 2.

Horizontal
Dial
A

Fig. 3.

Fig. 4.

Fig. 5.
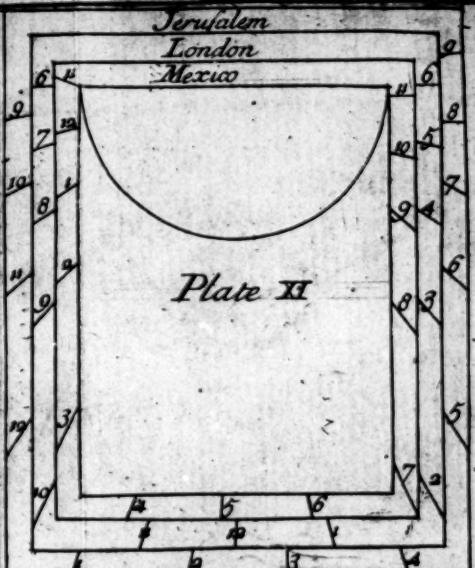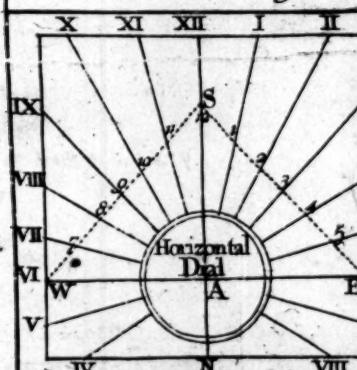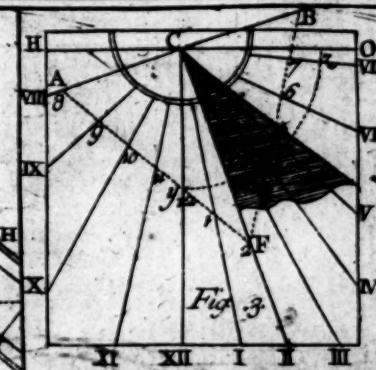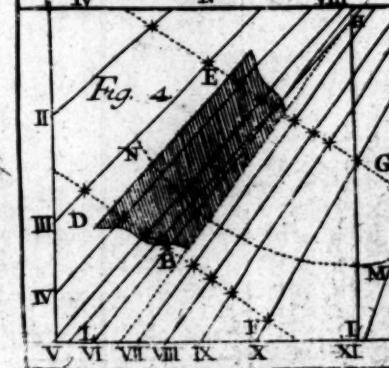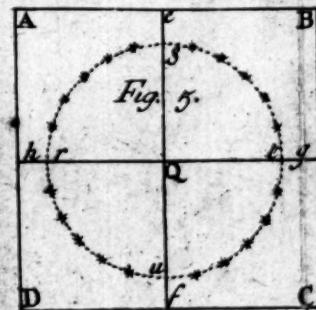
Fig. 6.
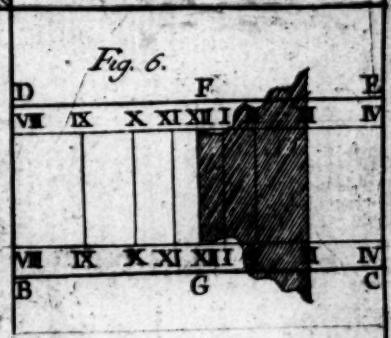
CHAP. XI.

Of Mechanick Dialling.

Teaching how to make any Plain Dial either Di-
rect, Declining, &c. without the Help of Mathe-
matical Calculation, or any Instrument, except on-
ly a plain Ruler, and a Pair of Compasses.

ALthough the Varieties of Dialling before
treated of, (*viz. Geometrical, Arithmetical,*
and *Instrumental*) might be thought sufficient,
yet because this Book may come into the Hands
of some that have not learned so much *Geo-*
metry, or *Trigonometry,* as to be capable to put
those Directions in Practice, or cannot procure
a Ruler with the Dialling Scales upon it (which
is the Case of many *Masons, Carpenters,* &c. in
the Country.) For the Sake of such I have ad-
ded this Chapter, whereby any Person that can
but read and write, will be able to draw a *Di-*
al upon any *Plain,* provided he can raise or let
fall a Perpendicular, and draw a Line parallel
to a Line given, &c. which is taught at the Be-
ginning of this Book.

SECTION I.

How to describe the Hour-lines upon a Horizontal Dial.

I Shall, to avoid needless Repetitions, forbear to give any general Directions, and fall directly upon an Example. Let it therefore be required to draw a *Horizontal Dial* for Latitude 51 deg. 30 min.

First, Through the Middle of your Plain draw the Line A B for the Meridian, or 12 a-Clock Line, and some where near the Middle of it, as at Q, cross it at right Angles with the Line 6 6, then with any Extent of your Compasses, and one Foot in the Center Q, with the other describe the Quadrant E B, which divide into 90 Parts thus ; *First*, with the same Extent of your Compasses, with which you swept the Quadrant, and one Foot in B, set the other towards E, and there make a Mark, for that is 60 deg. then with the same Extent and one Foot in E, set the other towards B, making also a Mark, thus is the Quadrant divided into three equal Parts, each containing 30 deg. Divide each of these Parts again into three equal Parts, then is each of these last Divisions into two equal Parts, each of which will be 5 deg. And lastly, divide each of these last into 5 parts; so will the Quadrant be divided into 90 equal Parts or Degrees.

Plate 12, *Fig.* 1.

Now

Now becaufe the Latitude propofed is 51½ degrees, count 51½ of thofe 90 deg. from B towards E, which will reach to Z; then from the Center Q draw the Line Q Z for the Stile; affume a Point any where at pleafure, in the 12 a Clock Line, as at C, through which draw the Line L F parallel to the Line 6 6; this laft Line we will for Diftinction call the Tangent-line. Place one Foot of your Compaffes in the Interfection of the Meridian and Tangent-line, as at C, and with the other take the neareft Diftance to the Stile Q Z, and keeping one Foot ftill in C, turn the other about, till it cut the Meridian-line in D; then upon D as a Center, with the fame Extent D C, draw the Semicircle H C G, and draw the Diameter H D G parallel to L F, then with the fame Extent, with which you draw the Semicircle, and one Foot in C, turn the other Foot both ways towards H and G, and there make Marks, alfo with the fame Extent, and one Foot in G, turn the other towards C, and where it falls upon the Semicircle make a Mark, then with the fame Extent, and one Foot in H, turn the other towards C, and there alfo make a Mark, then is the Semicircle divided into 6 equal Parts; divide each of thefe Parts into two, and then it will be divided into 12 equal Parts; lay a Ruler from D, the Center of the Semicircle, over every one of thefe Divifions, it will cut the Tangent-line in the Marks ✳ ✳ ✳, &c. And *Laftly*, from the Center Q draw Lines through the Marks ✳ ✳ ✳, &c. in the Tangent-line, they fhall be the true Hour-lines of the *Dial.*

If you defire to have the half Hours and Quarters, you muft divide each of the 12 Divifions of your Semicircle into Halfs and Quarters, and

U   tranf-

transfer them to the Tangent-line, and from thence from the Center to the Dial, as you did the Hour-lines.

The Lines being thus drawn, place 12 at the Middle or Meridian-line, and proceed towards the right Hand with 1, 2, 3, 4, 5. &c. and towards the left with 11, 10, 9, 8, &c. and for the Hours of 4 and 5 in the Morning, and 7 and 8 at Night, they are found by continuing the Hours of 4 and 5 in the Afternoon, and 7 and 8 in the Morning, quite through the Center, as you see in the Figure.

The *Stile* is to be a thin Plate of Brass, or the like, made in the Form of the Triangle B Q Z, to be erected perpendicularly upon the Line Q B, the Side Q B of the Stile, upon the Line Q B, and the Angular Point at Q, and then is your Dial finished.

S E C T. II.

How to describe Hour-lines upon an Erect Direct South Dial. Plate 12. Fig. 2.

LET it be required to describe a South Dial for Latitude 51 deg. 30 min.

First, Through the middle of the *Plain* draw the Line A B, and at the upper End thereof, as at A, cross it at right Angles, with the Line 6 A 6 for 6 a Clock, or an East and West Line; then with as large an Extent of your Compasses as your Plain will admit of, and one Foot in A, describe the Quadrant B C, which divide into

90 Parts or Degrees, as you were taught Sect. 1.
of which set 38, 30 the Complement of the Latitude from B to E, and draw A E for the Stile,
then assume a Point at pleasure in the Line A B,
as at F, through which draw the Line O F H,
perpendicular to A B for a Tangent-line ; with
one Foot of your Compasses in F, with the other
take the nearest Distance to the Stile A E, and
keeping that Foot still in F, turn the other till
it cut the Meridian-line A B in G, then letting
that Foot rest in G, with the other describe the
Semicircle I F L, which divide into 12 equal
Parts, as you were taught to divide the like Semicircle in *Sect.* 1. of this Chapter. Lay a Ruler from G, over the equal Divisions in the Semicircle, and it will cut the Tangent-line OFH
in the Marks * * *, &c. *Lastly*, Draw Lines
from the Center A through the Marks * * *,
&c. in the Tangent-line, they shall be the true
Hour-lines of the Dial.

Having thus finished the Hour-lines, place 12
at the End of the Line A B, and (supposing
the *Dial* to face the *South*, and your Face towards
it) proceed with 1, 2, 3, &c. towards the
right Hand, and with 11, 10, 9, &c. towards the
left Hand, always observing that a *South* Dial can
never contain any more Hours than those from 6
in the Morning, to 6 in the Evening.

The *Stile* may be a Plate of Brass, or the
like, in Form of the Triangle, B A E, the
Side B A to be set upon the Line B A perpendicular to the Plain of the *Dial*, the Angle A of
the Stile being just at the Center or Point A of
the *Dial*, and then is your Dial finished.

U 3   SECT.

SECTION. III.

Of an Erect Direct North Dial.

THE *Erect Direct North Dial* is made by the same Rules as a *South Dial* is made, the Hour-lines and Stile being the same, only in a North Dial the Stile points upwards, making also an Angle with the Plain of the *Dial* equal to the Complement of Latitude ; and for the rest observe.

1. To put on no more Hours than are of Use, as at *London,* 4, 5, 6, 7, 8, in the Morning, and 4, 5, 6, 7, 8, in the Evening; the Sun never shining on a North Plain at any other Hours.

2. That (though the Divisions are the same) the Hours, which on the *South Dial* are marked 6, 7, 8, in the Morning, must on the *North Dial* be marked 4, 5, 6, in the Morning ; and the Hours of 4, 5, 6, in the Afternoon, must be 6, 7, 8, in the Evening.

3. Because upon a *South Dial* you never draw any Hour before 6 in the Morning, or after 6 in the Evening ; but the *North Dial* (at *London*) takes in 4 and 5 in the Morning, and 7 and 8 in the Evening : Therefore to supply that on the *North Dial,* you need but continue the Hour-lines of 4 and 5 in the Afternoon quite through the Center, and that gives you the Hour lines of 4 and 5 in the Morning on the opposite Side, and the Hour-lines of 7 and 8 also continued,

gives

gives you the Hours of 7 and 8 in the Evening.

4. As for what Hours are neceſſary to be put upon a *North Dial* in any other Latitude, I ſhall refer you to the Table (*Page* 190.) with its Explanation immediately following ; there you have the Length of the *Longeſt Day* in all Latitudes, whereby you may find the Sun's Riſing and Setting in all Latitudes, and conſequently know what Hours in the Morning or Evening are proper to be put upon a *North Dial*, it being ſuperfluous to put on the Hours before Sun-riſe, or after Sun ſet.

5. If a *North Dial* for any given Latitude be required to be made, take a Sheet of Oyl'd Paper, and proceed in all Reſpects by the foregoing Directions to make a *South Dial* for the Latitude propoſed, (only you may ſave the Labour of working for the Hours that you know will be of no uſe) which done, turn the Paper over, taking that End towards you which was fartheſt from you, and you will ſee through the Paper the true *North Dial* required, which I think will not need any further Explanation.

SECT. IV.

How to deſcribe an Erect Direct Eaſt Dial.
Plate 12. *Fig.* 3.

HAving prepared your Plain W X Y Z, whether Wood, Braſs, &c. Draw towards one Side of it the Line A B parallel to W Z, and in that Line chuſe a convenient Point towards the upper End thereof, as C, upon which as a Center, with any Extent of your Compaſſes deſcribe the

Arch

Arch D E, upon which from E, set off the Complement of Latitude, which in this Example we will suppose to be Latitude 54 deg. whose Complement to 90 is 36, set off therefore 36 deg. from E to D, and draw D C for the *Axis* of the World, then cross this Line at Right Angles with the Line C F, drawing C F both Ways to the Edges of the Plain ; chuse any convenient Point in the Line C F, as at 6, from which draw the Line 6 6 parallel to C D for the Substile and Hour-line of 6, (which in *East* or *West Dials* are always the same) continue the Line 6 6 at Pleasure, as to G, with the Extent from G to the Line C F, keeping one Foot of the Compasses in G, with the other describe the Semicircle Q R, which divide into 6 equal Parts both Ways from the Line G 6, and laying a Ruler from G over these Divisions, it will cut the Tangent-line C F in the Points ✳ ✳ ✳, *&c*. from every one of which Marks draw Lines parallel to C D, they shall be the Hour-lines required, which (beginning at 6) must be numbred upwards with 5 4, and downwards with 7, 8, 9, 10, 11, the Hour of 12 can never come into an *East Plain*, because at that Hour the Sun being upon the Meridian, is just upon the Edge of the *Plain*.

The Stile is a thin Plate to be fixed upon the Hour-line of 6 perpendicular to the *Plain* of the *Dial*, being from End to End, equally of the Height of the Line G 6, the Extent with which you drew the Semicircle.

S E C T.

SECTION V.

Of an Erect Direct Weſt Dial.

AN Erect Direct Weſt *Dial* is deſcribed in all Reſpects by the Rules given for the *Eaſt Dial*, only appear differently in two Particulars.

1. The *Eaſt Dial* is elevated towards the Left Hand, but the *Weſt Dial* is elevated towards the Right Hand, as the *Eaſt Dial* would appear, if ſeen through the Paper, the Diviſions being alſo exactly the ſame.

2. Whereas the *Eaſt Dial* contains the Forenoon Hours, and is numbred from the upper part downwards, with 4, 5, 6, 7, 8, 9, 10, 11, the *Weſt Dial* contains the Afternoon Hours, and is numbred from the lower End upwards, with 1, 2, 3, 4, 5, 6, 7, 8, the Stile being the ſame, and ſtanding upon the Hour-line of 6 in both.

For the Figure of a *Weſt Dial*, See *Plate* 3. *Fig.* 2.

SECT. VI.

How to deſcribe the Hour-lines, &c. *upon an Erect South (or North Dial) declining Eaſt.*

ALthough we have given Directions (Chap. 2. Page 34.) for finding the Declination of any Plain, yet theſe Directions requiring ſome Knowledge in Aſtronomy previous to the Practice

ctice of them, and this being defigned for the Ufe of thofe that have not acquired a fufficient Knowledge in the Mathematicks, I fhall give a Method, whereby (Mechanically) to take the Declination of any Plain, as followeth.

Take a fine board of Wainfcot, or the like, of about a Foot fquare, or more or lefs at Pleafure, and plain it very fine, or elfe pafte a Sheet of ftrong white Paper very fmooth, on one Side of it, as you fee in the Figure, the Board reprefented by A B C D. From the middle of the Side A B, erect the Perpendicular x y z, and in the Middle thereof, as at y, place one Foot of your Compaffes, and with the other Point at feveral different Extents, draw the *Concentrick Circles*, as you fee in the Figure, (it matters not what Diftance they are from each other, or whether they be equally diftant among themfelves) this done, erect a fmall Pin of 3 or 4 Inches in Length, exactly perpendicular in the Center of the Circles, and then is your Inftrument ready for ufe.

Plate 12. *Fig.* 4.

Note, If you are doubtful of your Performance in erecting the Pin exactly perpendicular, you may place the Pin before you make the Circles, and then with one Foot of your Compaffes in the Middle of the Top of the Pin, with the other defcribe the Circles as before, and then you are fure that the Middle of the Top of the Pin, where you placed your Compaffes, is perpendicular to the (fuppofed) Center of the *Circles*, whether the Pin be perpendicular to the Plain, or no, and then draw a Line perpendicular to the Side A B, and to cut each *Circle* exactly in two Parts, proceed to make ufe of the Inftrument, as followeth.

Place

Place the Inftrument exactly parallel to the Horizon, with the Side A B againft the Wall or Plain, whofe Declination you defire to know, and then about 7, 8, or 9, in the Morning, (when the Sun is clear of the Refraction of the Horizon, and before 10 or 11 a Clock, becaufe then the Sun rifes but flowly) obferve, which of the *Concentrick Circles* the Top of the Shadow of the Pin cuts, and where it cuts it, and there make a Mark. This done, let your Inftrument ftand un-removed till the Afternoon, and then wait till the Top of the Shadow cuts the fame *Circle* again (for all the Time between the Obfervations the Top of the Shadow will cut the inner *Circles*) and there where it cuts the fame *Circle* make a Mark, then divide the Space between thefe two Marks into two equal Parts, and in the exact Middle between them, on the fame *Circle*, make another Mark, for that fhall be the true North Point ; then (as you were taught in *Sect.* 1. of this *Chapter*, or by the help of a Line of *Chords* on a Sector, if you have it) find how many Degrees are contained between the laft Mark found, and the Point where the Line x y z cuts the fame *Circle*, for that is the Declination of the *Dial* ; and if the Mark laft found falls on the Eaft-fide of the Line x y z, the *Dial* declines Eaft, if on the Weft-fide, it declines Weft, but if the Line be juft in the Middle between the two Marks, it is a true South Plain, and hath no Declination at all.

Note, In your Morning and Afternoon Obfervation, as above, you need not regard the Hour of the Day, nor the Sun's Altitude, fo as to know what they are, but only obferve the two Points, where the Top of the Shadow cuts the fame Circle as before, and if at your firft begin-

ning

ning in the Morning, the Top of the Shadow doth not fall exactly upon a *Circle*, wait till it doth ; for as the Sun rises the Shadow passeth from one *Circle* to another, *viz.* from the greater to the lesser, and the contrary at his falling in the Afternoon.

Having thus found the Declination of the Plain, your next Work is to proceed to make the *Dial,* which for an Example, shall be a South Dial declining East 40 deg. for Latitude 54 deg. 00 min.

In performing the Work of this one *Dial,* you have also made three more, as is farther demonstrated Page 50, and 51. and Plate 3. Fig. 4. to which I shall refer the Learner for farther Instruction in that Variety : But of these four the South declining East is that in the lower Part of the projection, for making of which, first, towards the upper part of your Plain, draw the Line E W for the East and West, or Horizontal-line, in which chuse a Point, as at A, for the *Center* of your *Dial,* upon which describe the Semicircle Z M E. Through the point A, in the Horizontal-line E A W, and at right Angles to it draw the Line A M, wh ch divides the Semicircle Z M E into two Quadrants, of which that towards the left Hand, *viz.* the Quadrant A Z M, serves for our present Purpose, because the *Dial* declines East, and consequently the Substile, *&c.* falls in that Quadrant : Therefore, set 40 deg. (the Plain's Declination) from M towards Z, upon the Arch M Z, and through the Point where that falls, and from the Center A, draw A D the Line of Declination, then set the Complement of Latitude, *viz.* 36 deg. (because the Latitude is 54, and its Complement to 90 is 36) from M the
<div align="right">same</div>

fame Way upon the fame Arch, and thro' the Mark where that falls, and from the Center A, draw the Polar Line A P, then affume a Point at pleafure in the *Horizontal-line* W A E, at a convenient Diftance from A, as at B, and from thence draw a Line parallel to A M, to cut the Polar Line A P in P. From P draw a Line parallel to the *Horizontal-line* W A E, as the Line P C. Take the Diftance A B upon the *Horizontal-line*, and fet on the Line A D from A to D, and through D draw a Line parallel to A M, to come into the *Horizontal-line* at R, and continue it thro' D till it cut the Line P C in S, a Ruler laid from A to S, and the Line A S drawn thereby, is the *Subftile* of the Dial. Then at the Point S erect a Perpendicular to the Line A S, as the Line S T. Set the Diftance R D from S to T, and draw the Line A T, fo fhall the Triangle S A T reprefent the Stile of the Dial; for a Triangular Plate in that Form, erected perpendicularly upon the *Subftile* A S, fhall by its upper fide A T caft a Shadow to the Hour of the Day, when the Hour-lines are drawn, which is the next thing to be done.

For drawing the Hour-lines, affume a Point in the *Subftile* at pleafure, through which and at right Angles with the *Subftile*, draw the Tangent-line F F as long as you can, and fetting one Foot of your Compaffes, where the Tangent-line cuts the *Subftilar*, take with the other the neareft Diftance to the *Stile*, or Line A T, and with the fame Extent, one Foot remaining in the Point of Interfection, with the other find the Point Æ in the *Subftile*, and with the fame Extent (one Foot refting in Æ) defcribe the Semicircle m n; this done, lay a Ruler from Æ, (the *Center* of the *Semicircle*) to the Point where
the

the Tangent-line F F cuts the Meridian A M, as at O ; begin at O to divide the Semicircle into 12 equal Parts, at every one of which make a Mark. Then lay a *Scale* from Æ, the Center of the *Semicirle*, over the said Marks, it will cut the Tangent-line in the Marks * * * *, *&c.* And Lastly, lay a *Scale* from A, the Center of the Dial, over these Marks * * *, *&c.* in the Tangent-line, and Lines drawn thereby will be the true Hour-lines of that Dial.

In this, as in a South Dial, the Hour of 12 is at the Meridian, or middle Line of the Dial, and the rest numbred forwards with 1 2, and backwards towards the left Hand with 11, 10, 9, 8, 7, 6, 5, 4, as you see in the Figure.

SECT. VII.

Of Dials declining from the South Westward. Plate 12. *Fig.* 5.

FIRST, Draw the *Horizontal-line* W A E, and upon the Point A in the Middle of it, as a *Center*, describe the Semicircle Z M E, as you see taught in the last Section for Dials declining from the South Eastward, and draw A M perpendicular to W E, which will divide the Semicircle Z M E into two Quadrants ; and as in the South East declining *Dial*, the Quadrant A Z M was of Use, so in this the Quadrant A E M must be made use of, because in it the *Sub-stile* and other Parts of the Work necessarily fall, and there is no Difference in the Operation, only instead of setting from A or M, *&c.* to the left Hand,

Hand in the laſt, you ſet from A or M, even to
the right Hand in this; ſo that if the laſt had
been drawn upon oyl'd Paper, or any other tranſ-
parent thing, ſo as to be ſeen through on the
back ſide of the Paper, it would be exactly a
South Dial declining Weſt, as far as the other
did Eaſt, and for the ſame Latitude only, the 11
muſt be 1, and the 10 muſt be 2, and ſo is the
reſt, and the North Decliners are alſo deduced
therefrom, as is taught at large Page 50 and 51,
before-mentioned.

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SECTION VIII.

Of Eaſt or Weſt Reclining, or Inclining Dials.

ALthough we have given Directions (Page
125,) for reducing Eaſt and Weſt Recliners
for any given Latitude to new Latitudes and
new Declinations, and ſo may be performed by
the Directions given in Sect. 6. and 7. of Mecha-
nick Dialling, yet I ſhall here, for the Learner's
Improvement, ſhew how they may be done
Mechanically without any ſuch Alteration, whether
they be Eaſt or Weſt, Reclining, or Inclining.

It will be neceſſary firſt to premiſe, that Eaſt
and Weſt Recliners have their Centers near the
Bottom, and in this the Incliners of both ſorts
have their Centers near the Top: The Weſt Re-
cliner and Eaſt Incliner ſhould have their Cen-
ters toward the right Hand, and the Weſt In-
cliners and Eaſt Recliners have their Centers
moſt commodiouſly towards the left Hand:
Therefore,

X   Suppoſe

Suppose I would make an East Dial to recline 45 deg. for Latitude 54 deg.

Having prepared my square Plain W X Y Z, I consider by the foregoing Rules where I may most conveniently chuse my Center ; and I find first, that all Recliners both East and West, have their Centers at or near the Bottom ; and secondly, I find that East Recliners should have their Centers most towards the left Hand ; therefore at the Bottom of the Square W X Y Z, draw the Line S N for the Meridian, in which, not at the Middle, but rather towards the left Hand, as at A, I chuse the Center, and from A perpendicular to the Line S N, draw A E ; also with one Foot of your Compasses in A, describe the Quadrant T U, and set off 45 Degrees (the Reclination of the Plain) from T towards U, and through that Point in the Quadrant where the 45 degrees end, and from the Center A, draw the Line A O. Also set off upon the same Quadrant from T, the Complement of Latitude 36 degrees, and thro' the point where that reaches upon the Quadrant, and from the Center A, draw the Line A P ; then in the Meridian Line N S chuse a point at pleasure, as B, and from that Point draw a Line parallel to A E, which will cut the Line A P in P. From that Intersection at P, draw a Line parallel to the Meridian-line S N, to come to the Perpendicular A E in C ; and also from the Line A O in O, take the Distance A O, and set upon the Perpendicular A E, from A to E, and draw E G parallel to S N, which will cut B P continued in G ; set also the Distance C O from A to Q, upon the Line A O, and draw the Line Q R parallel to B P ; take also in your Com-

Plate 12.
Fig. 6.

Compasses the Distance A R (from the Line S N) and set it off upon the Line G B, from G to S, a Line drawn from A to S shall be the *Sub-stile* of the *Dial*. Draw S M perpendicular to A S, and take in your Compasses the Distance Q R, and set from S to M, and laying a Ruler from the Center A to M, a Line drawn by it shall be the *Stilar* Line, the Triangle A S M repre-senting the *Stile*, which being erected perpendi-cular to the Plain of the Dial upon the *Subftile* A S, shall give the Hour by the Shadow of its upper Edge, which will be parallel to the Axis of the World.

For drawing the Hour lines, chuse a point at pleasure in the Subftile A S, and through that at right Angles draw the Tangent-line I K as long as you can, and with one Foot of your Compasses in the Point where the Tangent-line I K crosses the *Subftile* A S, take with the other the nearest Distance to the *Stile* A M, which done, (keeping the other Foot yet in the afore-said Interfection) turn the Compasses about, till it cuts the Subftile A S, as in Æ, and fixing that point in Æ, with the other at the same Extent describe the *Semicircle* I n; draw a Line from Æ the Center of the *Semicircle*, to the point where the Tangent-line I K, cuts the Perpendicular, and observe where it cuts the Semicircle, and there begin to divide it into 12 equal parts. A Ruler laid from Æ over the equal Divisions of the *Semicircle*, will cut the Tangent-line I K un-equally in the Points ✳ ✳ ✳, &c. And *Laft-ly*, a Ruler laid from the Center A to thefe Marks ✳ ✳ ✳, &c. in the Tangent-line, and Lines drawn thereby, shall be the true Hour-lines required.

The

The Line S N being the Meridian and Hour-line of 12, you muſt place 12 at the End of it, and the reſt 11, 10, 9, 8, 7, 6, 5, 4, as you ſee in the Figure.

In drawing this, you have in Effect drawn three more ; as,

1. If it was turned upſide down, the ſame ſide is a Weſt Dial inclining 45 deg. only the Hours are for the Afternoon, as for 11 put 1 for 10 2, and then the *Subſtile* will conſequently be as much on the right Hand of the Perpendicular, as now it is on the left.

2. If it was drawn on oyl'd Paper, the Back-ſide would be a Weſt Dial reclining 45 deg. only the Figures inſtead of 12, 11, 10, 9, &c. muſt be 12, 1, 2, 3, &c.

3. If the Meridian-line S N be turned upwards, the Back-ſide will be an Eaſt Dial, inclining 45 deg. and the Figures, as they are, only the Subſtile muſt be as far to the Left Hand of the Perpendicular A E, as now it is on the Right.

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SECT. IX.

Of Direct South or North Plains Inclining or Reclining.

IT is needleſs to give any Directions about Direct North or South Reclining or Inclining Dials, becauſe they are erect direct North or South Dials in ſome other Latitude ; and how to reduce them to ſuch, you are fully taught in Sect. 5. of I*nſtrumental Dialling,* Page 192, 193, 194, and when they are reduced to direct North Dials

Dials in another Latitude, they are made by the Directions given, page 218, and 220, to which (to avoid Repetitions) I shall refer the Learner in this Case.

SECT. X.

To describe the Hour-lines upon a South or North Inclining, Declining, or Reclining Plain.

THESE Dials, though different in Situation, are the same as to the Method of Projection; for the South Inclining Declining, and North Inclining Declining, as also the South Reclining Declining, and likewise the North Reclining Declining, are the same, only differently placed, and are to be projected by the following Rules.

Note, You are taught in *Sect.* 10. of *Instrumental Dialling, Pag.* 205. how to reduce (*Pl.*12.*Fig.*7.) any Declining Reclining *Dial,* for any given Latitude, to a new Latitude and new Declination, where it will be an upright declining *Plain;* which being done, you may proceed according to the Directions given in *Sect.* 6. of *Mechanick Dialling, Pag.* 223, to 228; but because that requires *Trigonometrical Calculation* for finding the new Latitude, and new Declination, (which we suppose some *Mechanicks* are not capable of.) I shall shew, how it may be done without any *Trigonometrical Operation* whatsoever.

I shall instance in a *South Dial* declining East 26 deg. and inclining 36 deg. for Latitude 51 deg. 30 min.

Draw a Line on the upper-side of your *Plain*

paral-

parallel to the *Horizon*, which mark with E W, *viz.* (becaufe the *Dial* faceth to the *Southward*) put E at the right Hand for Eaft, and W at the left Hand for Weft ; affume a Point in the Line E W, as at A, for a Center, upon which, with any Extent of your Compaffes, (the longer the better) draw the Quadrant x y, and through x draw the Line A x X perpendicular to W E ; divide the Quadrant into 90 Degrees, as you are taught in *Sect.* 1 of this Chapter, *Page* 216, or by a Line of Chords (the making of which I fhall fhew hereafter) which is much more expeditious, and upon thefe Degrees of the Quadrant, fet from x the Complement of Latitude 38 ½ deg. the Declination 26 deg. and the Inclination 36 deg. making Marks in the Quadrant where thefe Degrees fhall fall, and through thefe Points in the Quadrant, and from the Center A, draw the Lines A b, A c, and A d. Then chufe a Point in the Line E W, towards the Quadrant, as at B, from which draw a ftrait Line perpendicular to E W, or parallel to A X, as the Line B P, to cut the Line A d (the Line drawn from the Center A through the point where the Complement of Latitude, reaches in the Quadrant) in the point P, and through that Interfection at P draw the Line P C parallel to W E, which will cut the Line of Inclination A c in O. Take in your Compaffes the Extent A O, and fet on the Line A X from A to F, and through F draw F G parallel to P C, then take in your Compaffes the Extent C O, and fet it on the Line A X, from A to L, and draw L D parallel to W E, to cut the Line of Declination A b in D. Set the Diftance A B from A to V, upon the Line of Declination A b, and from V draw V K parallel

to

to W E, to cut the Line A X in K. Take in your Compaſſes the Extent V K, and ſet off upon the Line G F, (but on the contrary Side of the Perpendicular) from F to M, and draw M N parallel to A X, to cut the Line W E in the Point N. Then becauſe the Plain is a South *Incliner*, (or if it had been a North *Recliner* it had been the ſame) take in your Compaſſes the Diſtance L D, and ſet upon the Line F G, from F to H, for a Meridian Line, or the Hour-line of 12; take in your Compaſſes the Diſtance A L, and placing one Foot in K, extend the other to the Point X; then take the whole Diſtance A X, and ſet upon the Line of *Inclination* A c, from A to Q, and from Q draw Q R parallel to B G, to cut the Horizontal-line W E in R; take in your Compaſſes the Extent A R, and with one Foot in M, extend the other in the Line M N to the Point S, and draw the Line A S for the Subſtile, and draw S T perpendicular to A S, and upon the Line S M ſet the Diſtance Q R from S to T, and draw the Line A T for the Stile, ſo ſhall the Triangle A S T repreſent the Stile to be erected perpendicular to the Line A S, and to ſtand upon that Line, the Side A T being parallel to the Axis of the World, and its Shadow upon the Hour-lines determining the Hour of the Day.

For drawing the Hour-lines upon this Dial, chuſe a Point in the Subſtile A S, and through that Point, and perpendicular to A S, draw the Tangent-line E g to cut the Subſtile A S in the Point h, take the neareſt Diſtance from the Point of Interſection at h to the Stile A T, and keeping one Foot in h, turn the other about to the Point Æ, in the Subſtile A S, then keeping that Foot in Æ, with the other draw the Equinoctial Circle to touch the Tangent-line, then lay a Ruler

from

from Æ the Center of the Equinoctial-line, to the Point where the Tangent-line cuts the Meridian-line A H, as in the Point ⊙, and observe where that Ruler cuts the Equinoctial Circle, and from that Point begin to divide the Semicircle into 12 equal parts, as you were taught, *Page* 217. and then, as you have been formerly taught, lay a Ruler from the Center of the Æquinoctial at Æ over the equal Divisions in the Circle, and observe, where it cuts the Tangentline, as in the Points * * *, *&c.* And lastly, Lines drawn from the Center A through the Marks * * *, *&c.* shall be the true Hour-lines of that Dial.

For numbring the Hours, place 12 at the Meridian-line at H, and 1, 2 towards the right Hand, and 11, 10, 9, *&c.* towards the left Hand as far as the Hours extend.

Note, It is best in drawing this or any other Dial, to draw all the preparative Lines with Charcoal, or Black Lead, or the like, that they may be taken clean out, when you have put on the Hour-lines, and such other Furniture, as you think fit to put upon your Dial.

I might proceed to shew the Method of making Inclining Dials declining from the South-westward, as also North Recliners declining East and West, but they being all, (with a little Consideration) included in this, I shall only for the making of them give these general Rules.

1. An Incliner declining from the South-East ward, is what we have just now spoke of.

2. The Incliner declining to the South-west-ward, is done by the same Directions, only the Quadrant which in the East Decliners is on the right Hand Quarter below the Horizon, must in the West Decliners, or those that decline from the

the South-weſtward, and alſo incline, be in the left Hand Quarter below the Horizon or Line W E, which may be beſt conceived by ſuppoſing this Dial to be drawn on oyl'd Paper, and looking through the Paper, that which on the right Side of the Paper was an inclining Dial declining from the South-Eaſtward, will, (looking thro' the Paper) be an inclining Dial declining from the South Weſtward, &c.

3. A North declining Eaſt Recliner is the ſame of a South declining Eaſt Recliner, only the Horizontal-line W E muſt be at the Bottom of the Dial, and the Quadrant deſcribed thereon upon the Center A, muſt be above the Line Line E W, and towards the left Hand, and may be repreſented by a South declining Eaſt Recliner turn'd Bottom upwards with the ſame Side towards you as before.

4. A North declining Weſt reclining, is the ſame with a South declining Weſt inclining, only (as before) the Horizontal Line E W muſt be at the Bottom, together with the Center of the Dial, and the Quadrant muſt be above the Line, and towards the right Hand, and may be repreſented by the Dial already deſcribed, if imagin'd to be done upon oyl'd Paper, and ſeen through being turned Bottom upwards ; but of this ſee more, *Chap.* 27, *Page,* 110, and 111.

Note, The Hours on the North Dials muſt be numbred the contrary Way to thoſe of the South Dials, and for what Hours to put upon any North Dial, whether declining, reclining, &c. *See Chap,* 1. *Sect.* 10. *Page* 189.

I have not drawn the Hour-lines in the Dial now deſcribed, leſt it ſhould too much confuſe the Scheme, it being eaſy to imagine, where they

will

will fall, when drawn from the Center A thro'
the Marks ✳ ✳ ✳, &c. in the Tangent-line.

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SECT. XI.

*A very plain and easy Way to make a Dial, that shall
give the true Hour by Reflection on a Cieling, where
the direct Beams of the Sun can never come, and
shall represent the Sun's Motion as true and regu-
lar within the House, as his natural Motion is with-
out, provided the Window open to the Southward,
or so that the Sun may shine in or near it.*

TAKE a Piece of a clear Looking-glass, a-
bout three Quarters of an Inch broad, and
fix it in a Window that looks to the Southward,
(the nearer the Out-side of the Window that
it stands, the longer the Sun will shine upon
it, and therefore it would be better to make some
Conveniency to place it upon, quite without the
Window, that the Sun may shine upon the Glass
as long as it shines upon the Wall) and take care
to place your Glass very exactly parallel to the
Horizon, for if you mistake in that, you throw
all the Work amiss. This done, hold a Thread
with a Plummet exactly over the Glass, and ob-
serve where the Shadow of the Thread falls up-
on the Floor exactly at Noon, and there draw a
Line quite cross the Floor as far as you can, for
this will be a true Meridian, or North and South
Line; but if you have not the Opportunity of a
good Clock, Watch, or Dial, you may find the
                                        true

true North by the Directions given, *Page* 224,
and 225. and having by any Means found the
true North from the Glass, and thereby descri-
bed a Line upon the Floor, or (which is the
same) stretch'd a Thread directly North from
the Glass ; take a Thread and Plummet,
(the Plummet having its lower End brought
to a Point) and holding your Hand up against the
Cieling, with the Thread in your Hand, and the
Plummet playing freely, move your Hand to and
fro, till the Point of the Plummet rest over or
upon the Thread or Meridian-line before found,
and there where the upper End of the Thread
toucheth the Cieling, make a Mark. Do the
same at the other End of the Thread or Meridi-
an-line upon the Floor, and make another Mark
upon the Cieling ; then with a Carpenter's Line,
or a strait Ruler, draw a Right-line between
those two Points, which will be a true Meridi-
an, or North and South Line, upon the Cieling.
Then because the Sun's Meridian Altitude, when
in the Æquinoctial, is equal to the Complement
of Latitude of the Place, and because the Angle
of Reflection is always equal to the Angle of
Incidence, *viz.* a Line imagined to be drawn
from the reflected Spot upon the Cieling, to the
Middle of the Glass, makes always the same An-
gle with the Plain of the Glass, that a Line
drawn from the Sun to the same would do, it will
follow, that the Æquinoctial must cross the Me-
ridian just in that Point that makes an Angle with
the Plain of the Glass equal to the Complement
of Latitude of the Place, which Point in the Me-
ridian may be thus found.

Cause one Person to hold a Thread exactly
upon the Middle of the Glass, and stretching it
tight, hold the other End up to the Meridian

up

upon the Cieling, to make (as near as you can guess) an Angle with the Horizon equal to the Complement of Latitude; and holding it there, apply the Side of a Gunter's Quadrant to it, if it make too great an Angle, (keep that End fast upon the Glass, and) slip a little more of the Thread out of your Hand, and so moving gently to and fro, find where it makes just the requir'd Angle (as suppose of 38½, if it be for Latitude 51½ deg.) there make a Mark in the Meridian upon the Cieling, for there the Æquinoctial must cross it; therefore through that Mark draw a Line cross the Cieling at right Angles, with (or perpendicular to) the Meridian, to represent the Æquinoctial.

Note, It may be as well to put the Thread through the Holes in the Sights of the Gunter's Quadrants, and letting the Plummet play freely, proceed as before.

Keep your Thread still fast, one End in the middle of the Glass, and the other End in the Point, where the Æquinoctial cuts the Meridian in the Cieling, turn your Quadrant with its Center to the Center of the Glass, and its Side or Semidiameter exactly along by the Thread, propping or otherwise securing it that it may not stir, then (because every 15 Degrees of the Æquinoctial is an Hour of Time) remove the String 15 Degrees of the Quadrant, and observe where it cuts the Æquinoctial, when stretched to it, and there make a Mark; do the like for the next Hour, removing the Thread to 30 Degrees, and stretching it to the Æquinoctial, make a Mark, where it cuts it; do the like at 45 deg. 60, &c. as far as you can, which done, remove your Quadrant to the other Side of the Meridian, and setting of 15, 30, 45, 60, &c. Degrees, make

Marks

Marks on the other half of the Æquinoctial, and fo you have the Points where the Hour-lines interfect the Æquinoctial, which are to be numbred with 12, where the Meridian cuts the Æquinoctial, and from thence Eaftward with 1, 2, 3, &c. and Weftward with 11, 10, 9, &c. as far as the Room extends.

Note, You may continue the Æquinoctial down by the Sides or Walls of the Room, as well as upon the Cieling over it; if you continue the Quadrant at the aforefaid Elevation, and cont nue the Æquinoctial down the Wall, fo as that it may juft coincide with the Plain of the Quadrant, which may be done by continuing the Thread parallel to the Plain of the Quadrant till it touch the Wall; and though the Wall be never fo irregular, the Æquinoctial may be by this Means continned, and the Hours upon the Wall as well as the Cieling, may be found by every 15 deg. removing the Thread.

As for the *Hour-lines*, they are to pafs thro' thefe feveral Points found in the *Equinoctial* by the aforefaid Means, but they muft not cut the *Equinoctial* at *right Angles*. To find the Center, or Point of Interfection of the Hour-lines will be difficult, becaufe it falls without the Room in the Air, for as the Æquinoctial is elevated equal to the Complement of Latitude, fo the Pole is elevated equal to the Latitude; and as the elevated Pole is to the Northward from us, and a Line, fuppos'd to be drawn from it to the Center of the Glafs, will make with the Horizon an Angle equal to the Latitude of the Place, fo the reflected Axis of the World fhall defcribe an infinite Line in the Air to the Southward, making with the Horizon the fame Angle.

Y

But

But becaufe the Pole or Center of the Æqui-
noctial falls without in the Air, it is not fo eafi-
ly acceffible for drawing the Hour-lines; there-
fore to remedy that Inconveniency, obferve by
the Directions given, (Sect. 1.) *For drawing an Ho-*
rizontal Dial, what Angle every Hour-line makes
with the Meridian, and in this Cafe, they muft
make an Angle equal to the Complement of the
fame Angle with the Æquinoctial. As for Ex-
ample,

Suppofe I would make an Horizontal Dial
for Latitude 51 Degrees, 32 Minutes North.
I fhall find by the Directions given, Sect. 1.
that the Hour-lines make Angles with the Me-
ridian, as followeth.

				d.	m.
12				0	0
11	1			11	50
10	2			24	20
9	3	makes an Angle of	{	38	3
8	4			53	35
7	5			71	6
6				90	0

These are the Angles that each Hour-line
makes with the Meridian; their Comple-
ments to be made with the Æquinoctial,
are,

For

			d.	m.
12			90	0
11	1		78	10
10	2	The Angle with	65	40
For 9	3	the Æquinocti-	51	57
8	4	al is	36	25
7	5		18	54
6			0	0

Therefore, if through the feveral Points found in the Æquinoctial for the Hours, you draw Lines to make the laft before-mentioned Angles with the Æquinoctial, they fhall be the feveral Hour-lines required, and the Sun fhining upon the Glafs, fhall reflect the Light at any Time of the Year upon the Hour of the Day.

Note, What is faid here of the Angles which the Hour-lines make with the Æquinoctial, is meant while the Æquinoctial is continued upon the Cieling parallel to the Horizon, and not with Refpect to its being continued down the Wall.

Y 2 **SECT.**

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SECT. XII.

How to make a Line of Chords, whereby any Number of Degrees may easily be set off upon any Circle, without the fore-mentioned Trouble of dividing it.

DEscribe a Semicircle, and divide the Circumference of it exactly into two equal Parts at c, then divide either of the Quadrants (as suppose b c) into 90 equal Parts, as you are directed in the first Section of *Mechanick Dialling*, and you may draw the Line b c. Then upon the Plain where you intend to make your Line of Chords (whether upon a Ruler, a Paper, or Board) draw a handsome double Line and a single Line at a competent Distance from it, so as to leave Room between them for the Figures, as you see *Fig.* 9. and let these Lines be exactly the Length of the Line b c, from A to B, which done, and the Quadrant very carefully divided into 90 equal Parts, as before directed, take a Pair of Compasses, and placing one Foot in the Point b, extend the other to the End of the first Degree, and keeping that Extent, place one Foot in the End of the double Line at A, and make a Mark where the other falls in the said Line, then again placing one Foot in b, as before, extend the other to the End of the second Degree, and set the same Extent on the
Line

Plate 12.
Fig. 8.

Line A B from A towards B, and where that falls
make another Mark. Proceed in the same Man-
ner with the third, fourth, or fifth Degrees, &c.
till you have thus transferred all the 90 Degrees
of the Quadrant to the Line A B, (which if
right done, will be unequal upon the Line A B,
being largest at first, and lessening gradually to-
wards the last) always observing at every Tenth
Degree, as 10, 20, 30, &c. to carry the Divi-
sion, through the single Line, and upon these Di-
visions place the Numbers, 10, 20, 30, &c.
for the more immediate Number of the Degrees,
the intermediate Degrees between every 10, be-
ing to be numbred from the next less even ten,
as the third small Division beyond 30 is 33, &c.
and then is your Line of Chords finished.

It is always observed, that the Chord of 60 is
equal to Radius, that is, when a right Line is
truly divided by these Directions, the Extent
from the Beginning of the Line at A to the 60
Degree, is just equal to g b the Semidiameter of
the Circle, by which the said Line was divided,
therefore in Practice, whenever you would draw
a Circle, that you propose to divide by your Line
of Chords, it must always be a Circle of the
same Bigness of that, by which your Line of
Chords was made, in order to which, whatsoe-
ver Line of Chords you intend to work with, take
60 Degrees of the same Chord, (that is, the Ex-
tent from the Beginning of the Line to 60) and
with that Extent, and one Foot where you in-
tend to make your Center, sweep a Circle, or a
half, or a quarter of a Circle, as you may have
Occasion, and when you have any given Number
of Degrees to set upon the Circle, from any
given Point, extend your Compasses from the
Beginning of the Line of Chords to the Degree

pro-

proposed, and with that Extent, and one Foot
in the given Point, observe where the other
Point falls upou the Circle, and make a Mark;
for that is the Number of Degrees required.

EXAMPLE.

It is required to set 37 Degrees upon the Qua-
drant d c, from d towards c. Place one Foot of
your Compasses in the Beginning of the Line of
Chords at A, and extend the other to 37 De-
grees, (*viz.* to seven small Divisions beyond the
Number 30) then with that Extent applied to
the Circle, one Foot in the given Point d, the
other will reach to n, the Quantity of 37 deg.
required.

To measure a given Arch of a Circle, is just
the Reverse of this ; for, take the given Arch,
or the Distance between the two given Points in
a Circle in your Compasses, and apply that Ex-
tent upon your Line of Chords, (always putting
one Foot upon the Beginning of the Line) the
moveable Foot falls upon the Degree required.

EXAMPLE.

It is required to measure the Arch d n in the
Semicircle d c b. Place one Foot of your Com-
passes in d, and the other in n, that Extent ap-
ply'd to the Chords, gives 37 deg. *&c.*

But no Line of Chords will measure any Cir-
cle, but those of the same Diameter with that
from whom the Line is projected ; therefore it
may be proper to make or have Lines of several
Radius's; but if you have not such Variety, that
Deficiency may be in some Measure remedied
thus :

To

To meafure any Part of any Circle, (whether it be to a larger or leffer Radius than your Chords are made for, it matters not) take in your Compaffes the Chord of 60 deg. from your Scale, and with one Foot in the Center of the Circle that is to be meafured, draw a Circle which will be parallel to the Circle to be meafured, but whether within or without, it is the fame ; but in this cafe, we will fuppofe it falls without the Circle that you would meafure. Lay a ftrait Ruler from the Center to the Point, from whence your Number of Degrees is to be fet off, and obferve where it cuts the Circle laft drawn, and make a Mark, from which fet the given Number of Degrees, and where the Degrees end, and from the Center, lay a Ruler, and obferve where it cuts the firft Circle ; for between that Point, and the Point firft propofed, is the Number of Degrees required to be fet off.

EXAMPLE.

In the Semicircle x y z, it is required to fet off 37 deg. from x towards y, but having no Chord to that Radius, take the common *Chord*, and with the Sweep of 60, draw the *Circle* d c b, upon which fet 37 deg. from d to n, and laying a Ruler from the Center to n, it cuts the inner *Circle* in o, and the Arch x o in the leffer *Circle*, is equal to d n in the greater ; viz. 37 deg. as required.

Plate 12. Fig. 8.

I fpeak of meafuring or fetting off promifcuoufly, one being the Reverfe of the other, and further Repetitions would be needlefs.

But

But the beſt Way of dealing with *Circles* of different Radius's, is by a Sector, whereon you have the *Chords* commonly marked C, which proceed from the *Center* to (near) the End of the ſame Side of both Legs, being exactly graduated alike; and in order therewith to meaſure any Part of any *Circle* of what Diameter ſoever, Firſt, Take in your *Compaſſes* the Radius or Semidiameter of the *Circle*, then open your Sector to that Wideneſs, that the *Compaſſes* (kept as they were) may reach from the Braſs Point at 60 on one Leg of the *Sector*, to the Braſs Pin or Point at 60 on the other Leg thereof; then if you would ſet off any Number of Degrees (ſuppoſe 45.) from any Point in the *Periphery* of the ſaid *Circle*, keeping your Sector at the ſame Opening, extend your *Compaſſes* from 45 on one Leg to 45 on the other, that Extent contains 45 Degrees of that *Circle*, and placing one Foot where the Leg in the other will find the Point where they end, and the ſame Method is to be uſed for *Circles* to any Radius or Arches containing any Number of Degrees.

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SECT. XIII.

How to make a Dial that ſhall give the true Hour of the Day, without a Stile or Gnomon, only by the Shadow of one Part of it appearing upon another Part thereof.

THERE is one of this Sort of Dials near the *South Weſt* Corner of *Middle Moorfields*, and in ſome other Places in *London*, but for the

ma-

making of them, you need have no Regard to
the Latitude of the Place, for that is to be con-
fidered in the placing and not in the making
of them ; in order to which, prepare a Piece of
Wood- Brafs, or Iron, of Bignefs at Pleafure,
in the Form of a Crofs, having one of
the Four-Ends longer than any of   *Plate* 12.
the other three, and let the Thick-   *Fig.* 9.
nefs of it be about equal to the
Length of one of the fhorter Ends, as you fee
in the Figure a b c d e f g h i k l m, where
b c and c d and l m are fuppofed equal, and
f g equal to h i, is longer than any of them ;
then for finding the Hours, take a Piece of plain
Plank, or Wainfcot, as long as the Line f g, and
as broad as the Length of the Line c d is intend-
ed to be in your Dial ; fuch a Piece is exactly re-
prefented by Parallellogram, or long Square, f g
h i, and which indeed may ferve for the Pur-
pofe following.

Take the Extent f i, or h g, (which are
equal) in your Compaffes, and with one Foot in
i, the very Interfection of the Side k e with the
Side a h, and draw the Quadrant f n, which di-
vide into 6 equal Parts for 6 Hours, becaufe it
is a Quarter of a Circle, and where thefe equal
Divifions fall, make the Marks, * * *, &c.
A Ruler laid from the *Center* i, through the
Marks * * *, &c. will cut the Line f g in the
Points r x z, &c. then the Pofition of this Dial
being to be with the End a b, to face the South,
and the upper part of the Dial to lie parallel
to the Æquinoctial, (not to the Horizon) the Sun
at 12 a Clock will fhine juft along the Line a
m or b c ; therefore place 12 at m and c, then
it is plain, that from 12 to 3, the Shadow of
the

the Corner a will pass along the Line m l ; therefore take from your Projection the Distance f r, and place from 12 to 1. Take also f x, and place from m to 2, and the Distance f z will be equal to m l ; therefore, at l place 3, and at 3 in the Afternoon the Shadow of the Corner a will go quite off the Side l m, but the Shadow of the Point e will become upon the Line f g as high as z ; therefore at z place 3, and at x place 4, and at r place 5, and then 6 must be in the Corner f, because at 6 the Sun will shine right along the Line e f, place 6 also at the Corner c, because the Sun at 6 shines right along the Line c d, and from 6 till 9 (if it be in a Latitude where the Sun continues up so late) the Shadow of the Corner at d is passing along the Line c b ; therefore take in your Compasses the Distance f r, and set from 6 to 7. Take also f x, and set from 6 to 8, and the Distance f z is equal to c b ; therefore at the Corner b place 9, because the Shadow of the Corner d goes off the Line b c at 9. Then for the Morning Hours, the Shadow of the Point l will enter upon the Line a m at the Point a just at 3 in the Morning ; therefore draw Lines from 7 and 8 in the Line b c, which let be drawn parallel to a b, or m c, and having placed 3 at the Corner a, place 4 upon the End of the Line that comes from 8 and 5, upon the End of the Line that comes from 7, and then 6 will be in the Corner m, because at 6 the Sun shines just along the Line l m, and from 6 till 9 the Shadow of the Point k is passing along the Side i h ; therefore having placed 6 in the Corner i, draw Lines from the Points r x z parallel to g h, and at the other End of these Lines, viz.

upon

upon the Side i h, place the Hours of 7 8 and
9, and when the Shadow of the Point k comes
at 9, the Shadow of the Point b is at the Point
d, and from 9 to 12, the Shadow of b paſſeth
along the Line d c, and at 12 the Shadow of
b is come to c; therefore take the Diſtances f
r, f x, and f z, and ſet from e to 11 and 10,
the Diſtance f z being juſt equal to c d, and
then is your Dial finiſhed; the Sun as it goes
off from one Part of it, comes on to another,
ſo that the Time of the Day may be always
found upon ſome Part or other of it, when
the Sun ſhines.

The Reaſon why theſe Dials require Thick-
neſs, as well as other Dimenſions, is, becauſe
being placed parallel to the Æquinoctial, the
Sun ſhines upon the upper Face all the Summer,
and at the Longeſt Day is elevated 23 ½ deg.
above the Plain of the Dial, and conſequently
the Shadow of a will fall at Noon in the Line
a m, but not in the Point m, but at an Angle of
23 ½ deg. therewith, which muſt be accounted
for in the Thickneſs of the Body of the Dial.

Note, It is not neceſſary that any one of the
Ends of the Dial ſhould be longer than ano-
ther, only for Ornament; but if you would
make one of thoſe Dials for any Place beyond
the Artick or Antartick Circles, where the Sun
is ſometimes ſeen all the 24 Hours, it is ne-
ceſſary all the Ends ſhould be alike, becauſe
then the Sun would come on to one Part as it
goes off from another continually, which now it
cannot, for the Sun coming up in the Morning,
the Shadow of g would have quitted the Line
f e at e, before the Shadow of l would come
on to the Line a m at a; but if f g was cut off
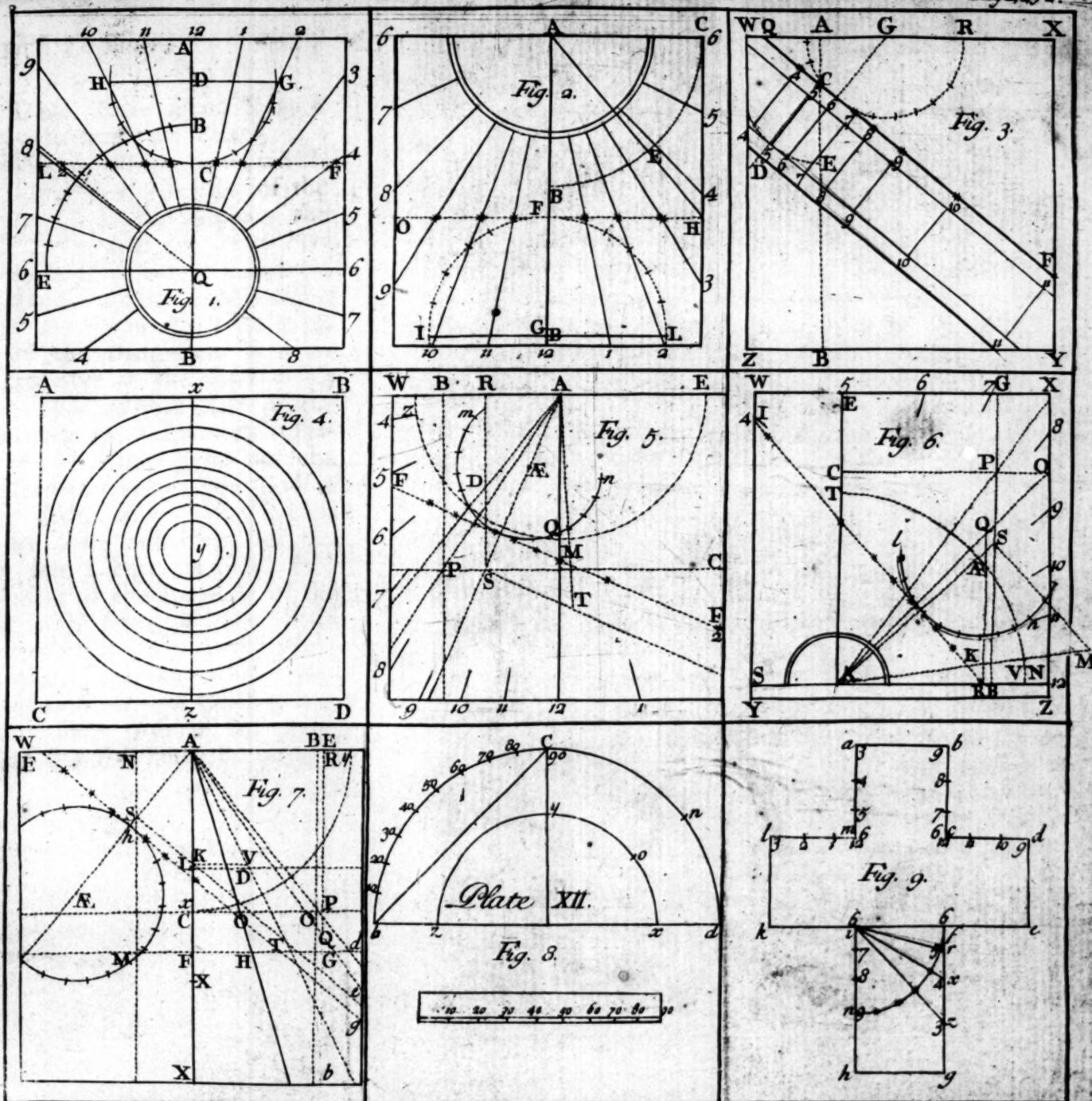at z, and f z made equal to a m, or m l, *&c.*

the

the Shadow of z would juſt quit e when the Shadow of l enters upon the Line a m at a.

The Sun's Place or Declination may be inſerted in theſe Dials as eaſily as in any ; for if you take in your Compaſſes the Extent a m, and with one Foot in the Point or Corner a, and with the other ſweep an Arch from the Corner at m downwards, and with that from a Chord to the ſame Radius, ſet off every 5 or 10 deg. of Declination, or the Sun's Declination at his Entrance into each of the Twelve Signs, being ſet off upon the Circle, and Lines drawn through theſe Marks to the Corner under m, and from thence parallel to b m, and c d will give the Sun's Entrance into the 12 Signs by the Shadow of the upper Point a, in the Summer Seaſon, while the Sun ſhines upon the upper Surface of the Dial, ; but in the Winter, the like Method muſt be uſed with the lower Part for the Southern Sign, the Declination increaſing upwards, and decreaſing downwards.

The Sun's Declinination at his Entrance into the 12 Signs, is as followeth.

	North Declination.			South Declination.	
	d.	m.		d.	m.
♈ Aries	0	0	♎ Libra	0	0
♉ Taurus	11	30	♏ Scorpio	11	30
♊ Gemini	20	12	♐ Sagittarius	20	12
♋ Cancer	23	30	♑ Capricornus	23	30
♌ Leo	20	12	♒ Aquarius	20	12
♍ Virgo	11	30	♓ Piſces	11	30

C H A P.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Plate XII.

Fig. 8.

Fig. 9.

In making thefe Dials, there is no Regard
to be had to the Latitude of the Place ; that
being to be confidered in placing them, which
muft be done fo, that the upper Face of the
Dial may be juft parallel to the Æquator, the
Line a m and b c, pointing at the South Part
thereof ; in Order to which, having found the
Meridian of the Place, fet the Dial exactly
North and South, and lay a ftrait Ruler a-
long the Middle of the Dial, from h g to
a b, letting it hang over at the End a b ;
then on the under fide of that Part of the
Ruler that hangs over, fix a Gunter's Qua-
drant with one of its ftrait Sides to the
Ruler, and the Center towards the End of
the Ruler ; which done, elevate the End a
b of your Dial by little and little, till the
Plummet (having free Liberty to play) falls
upon the Complement of the Latitude of the
Place ; or, (which is the fame) till the Plain
of the Dial make an Angle with the Horizon
equal to the aforefaid Complement of Lati-
tude ; then is your Dial fit for Obfervation,
there being always fome Side of it, upon
which the Hour of the Day may be feen, if
the Sun fhines.

Z CHAP.

CHAP. XII.

Of Painting of Dials.

SECTION I.

1. How to prepare your Oyl for laying on the Colour upon Dials.

TAKE one Gallon of Linfeed Oyl, and fet it upon a Charcoal Fire, and when it is about to boil, put into it two Pound of red Lead, and let it boyl together for about an Hour; but the beft way to know, when it is boiled enough, is to take a little of it out, and let it cool, and then if it roaps like thin Tar, it is enough. This done, put a lighted Paper to it, and fet it on Fire, to confume the greafy Part of it, which will be done in a Minute or two, or more or lefs, according to the Quantity of your Oyl, and when it has burnt long enough, clap a Cloath, or any other thing clofe over it, and extinguifh the Fire; after which, let it cool and fettle, then decant the clear Oyl from the Dregs, and keep it in a Bladder for ufe.

This is called drying Oyl, and with this the feveral Colours are to be ground, in order to paint, fo as to endure the Weather, (being firft dry, before it be expofed) the feveral Colours we fhall defcribe hereafter.

3. *How to make Gold Size, with which to lay on Leaf Gold.*

Take yellow Oker, and grind it with Water on a Stone, with a Muller, till it be very fine, and then lay it to dry, and when it is dry, take a Quantity of it, and grind it with the afore-mentioned drying Oyl, as you would grind other Colours, obferving to put fo much of each that it may be of competent Stiffnefs to work well, and of fuch a Body, that it may fettle itfelf fmooth when laid on, but not fo thin as to run; and take Care to grind it very fine, and it will add the greater Beauty to your Gold that is to be laid on with it.

S E C T. II.

Of Colours ufed in painting Sun-Dials.

THE Colours generally ufed in painting Sun-Dials, are,

1. For *White*, Cerufe and white Lead.
2. For *Black*, Lamp-black, Ivory-black, Charcoal and Seacoal-black.
3. For *Red*, Red Lead, Vermilion, and Cinnabar Lake.
4. For *Green*, Verdigreafe.
5. For *Blew*, Indico, blue Bice, blue Verditer, and Smalt.
6. For *Yellow*, Yellow Oker and yellow Pink.
7. For *Brown*, *Spanifh* Brown.

Z 2

Of these Colours you may compound Variety of other Colours, as,

1. A little Lamp-black with white, makes an Ash-colour.

2. Cinnabar Lake is a rich Crimson Colour, but mixt with Bice, it makes a fine Purple, according to the Proportion of Mixture; but mixt with white, it makes a fine Carnation.

3. Blew Bice mixed with yellow Pink, makes a Green; with Lake, a Purple; and with White, a light Blue. And note, that any Blue and Yellow mixed, make a Green of some sort or other.

4. Indico mixed with White, makes a Lead Colour.

5. Verdigrease mixt with Yellow Pink, makes a lively Grass Green.

By this Means may several other Colours be compounded, and made lighter or darker, at Pleasure, as a little Practice will make evident.

SECT. III.

How to prepare the Colours for Painting Sun-Dials.

BEFORE you proceed to the Painting of Sun-Dials in their several Colours, it is first necessary that they be primed; that is, painted two or three Times over with Oyl and Colour, prepared for that Purpose, to fill up the
Ca-

Cavities , which may (after plaining) remain in the Wood, and to make it perfectly plain, and the more capable to receive and retain other Colours ; and of all priming, *Spanish Brown* is reckoned to be the chief ; for, not to mention its Cheapnefs, it dries kindly, and gives the Oyl fufficient Time to penetrate into the Wood, and confequently alfo refifts the Weather, and alfo freely receives all other Colours which are laid upon it. It is of itfelf of a Horfe-flefh-colour, and, (befides its Ufefulnefs in priming) it is a natural Shadow for Vermillion, and may be made lighter or darker, according to the greater or lefs Quantity of white mixt with it ; but in priming, it requires not any Mixture, but only the Oyl itfelf.

In preparing the *Spanish Brown* for priming, grind it very well with the afore-mentioned drying Oyl, and make it for the firft priming, fomewhat thinner than you would do it for painting, that it may more eafily penetrate into the Wood ; which being dry, do it over again with the fame Mixture, only mix it a little thicker ; and letting that dry, do it a third Time, mixing your Colour thicker every Time. And take care in the priming, not only to rub the Brufh with the Priming upon the Dial, but alfo bob it againft it, that the Priming may be fure to pierce into all the Cavities, or Pores of the Wood. This done, and your Dial dry, the third Time it is ready for laying on the Colours, *viz.* Painting the Hour-lines, or what Ornament or Furniture you think fit to have upon it.

*If you are but for making a common Sun-Dial,
these Four sorts of Colours will be sufficient.*

1. *Spanish Brown*, which prepare, and there-
with prime your Dial, as before directed.

2. *White Lead*, well ground in Oyl, with
which, after the Priming is thoroughly dry,
go over it three or four Times, letting it
dry between every Time ; which not only
makes a beautiful white Ground, but fortifies
it yet more against the Fury of the Weather.

3. *Lamp-Black*, for drawing the Hour-lines
and Figures.

4. *Vermillion*, for drawing the Parallels of De-
clination, or what other Furniture you think
fit to put upon it.

The *Spanish Brown*, *Lamp-Black*, and *Vermillion*,
are all to be ground in the drying Oyl, descri-
bed at the Beginning of this Chapter ; and for
the *white Lead*, it is to be used in the same Man-
ner, only in making drying Oyl for white Lead,
instead of red Lead, use Litharge of Gold, and
proceed as before.

But if you would have your Dial more rich,
you must first consider, what Colours you re-
solve to have your Lines, Figures, &c. to be ;
and upon what Ground your determined Co-
lours will appear most beautiful, as,

1. Gold appears best upon a blue Ground,
and indifferently upon a Red.

2. Blue and Green appear best upon Yellow
and White.

3. Red sets off with Yellow, White, Blue,
or Green.

4. Yellow sets off with Black, Blue, and
Red.

Besides the Directions given already for preparing and laying on common Colours, it will be necessary to speak of the laying on the more rich and beautiful Colours ; and first,

How to lay on Leaf Gold, or to make any Lines, Figures, &c. of Leaf Gold upon your Dial.

Draw your Lines, Figures, or Letters, (or what you think fit to have in Gold) with Gold Size ; (of which before) which let dry so, that when you touch it with your Finger, it will stick, but not come off; then cut your Leaf Gold, as near as you can, into the Form you would have it, whether of Figures, Letters, Lines, &c. (taking Care to cut it rather too large, than too little) and with a flat Stick lin'd with Cloth, take up your Gold (so cut) and put it upon the Size, and the Gold will leave your lin'd Stick, and cleave to the Size ; then press it down with Cotton, or a Hare's Foot, and take care that you make the Figures, Lines, or Letters, in the Gold Size, and that you cut the Gold large enough to cover the Figures so made in the Size ; and when it is thoroughly dry, brush off all the loose Gold, and the Painting will remain beautiful, and be able to endure the Weather.

How to lay on Smalt, to make a fine Blue.

When you have laid on what you think fit in Leaf Gold ; Take white Lead, mix it pretty stiff with drying Oyl, and with a Pencil lay that on, where you intend your Blue shall be, and then put your Smalt in a fine Searce, and sift it on to the Dial, and with a Piece of Cotton,

ton, dab it down upon the white before laid
on, and when it is thoroughly dry, wipe off all
the loose Colour with a Feather, and blow off
the Dust with a pair of Bellows, which will
easily blow off, except what fell upon the white
before laid on to retain the Blue, which will
be a very beautiful Blue.

Observe as a general Rule, that Priming is
to be mixt or temper'd thin, but Colours for
Lines or Figures to endure the Weather, must be
temper'd thicker, the better to resist the Fury
of stormy, or moist Weather.
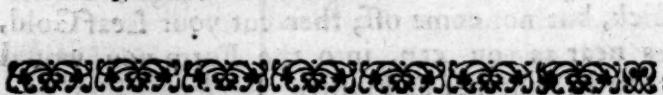
SECTION. IV.

Of the Nature and Colour of some of the principal
Ingredients used in Painting of Sun-Dials.

1. CERUSE and *White Lead*, are the only
Colours to be used in painting in Oyl, and
besides their Usefulness in painting of Dials,
Paint made up with them and Oyl, is fre-
quently made use of in painting Posts, Palisa-
does, Gates, Doors, Windows, Wainscoting,
&c. and answers the End of painting, both as
to Beauty and Preservation; ; for they dry well,
and strongly resist the Weather. But if you
would have them to dry yet more speedily, you
may in the tempering put in a little Oyl of Tur-
pentine, if it be within Doors, but without
Doors it is better without, because that does not,
so well resist the Weather.

2. *Lamp-*

2. *Lamp-Black* is a good Black, if it be firſt burnt, then ground, and laſtly, tempered with Oyl.

3. *Charcoal* is a Black that will ſerve for ordinary Uſes ; it dries well ; but great Care muſt be taken that it be well ground.

4. *Spaniſh Brown*, the beſt is a deep bright Colour, and free from Stones, and being very well ground, is the beſt for priming : It is of a Horſe-fleſh Colour, and a proper Shadow for Vermilion.

5. *Red Lead* is a great Dryer and Binder ; for which Reaſon, it is made uſe of in the drying Oyl ; it reſiſts the Weather as well as any Colour whatſoever.

6. *Vermilion* is a rich Colour, and of a good Body, but Care muſt be taken that it be finely ground, even as ſoft as Oyl, and then it will work extraordinary well : It is beſt to buy it in the Stone, leſt you meet with ſome that has been adulterated with Red Lead, or the like ; it is a perfect Scarlet of it ſelf, and may be altered to ſeveral Varieties, by mixing with other Colours.

7. *Cinnabar-Lake* is a rich Crimſon Colour, and muſt be very fine ground.

8. *Smalt* is a very fine Blue, and it is beſt to be ſtrewed on, as before taught ; for if you work it in Oyl, (though you waſh it, and mix it with white Lead) yet it will turn black in Time. If you buy it to work in Oyl, the fineſt is beſt, which is call'd *Oyl-Smalt*.

9. *Blue Bice* is a pale Colour, and works well though a little ſandy.

10. *Blue Verditer* is not ſo good a Blue as *Bice* and *Smalt*, though it may ſerve in Dial-painting.

ting, where they are wanting ; it is a little fan-
dy, and apt to fade and turn greenish.

11. *Indico* is a very dark Blue, and commonly
lightned with white, when us'd in painting, ex-
cept in shadowing ; it grinds fine, and is very
proper for the last Colour of Posts, Palisadoes,
Doors, Windows, *&c.* for it resists the Wea-
ther, and preserves the Wood.

12. *Blue Balls* are almost like Indico, but not
so good a Colour, nor will it endure so long.

13. *Umber* is a Hair colour, it must be very
fine ground, which to effect, requires a great
deal of Labour ; it dries and binds exceeding-
ly, and is therefore also very proper for pain-
ting without Doors, as Doors, Palisadoes, *&c.*
if calcin'd in a *Crucible*, it is a natural Shadow
for Gold, and some other Colours.

14. *Verdigrease* is a perfect Willow-Green, but
may be altered at Discretion, with Yellows, *&c.*
but being very foul, it must be mended or clean-
sed ; which may be thus done : *Grind it fine,
and put to it eight Times its Weight of Spirit of Vi-
negar ; digest till the Vinegar is tinged very green, then
decant the Colour ; cast away the Fæces, and evapo-
rate the Vinegar in a brass Vesica ; so have you a
very good Verdigrease at the Bottom, much more fine
and valuable, than before it was cleansed.* It dries
very speedily.

15. *Yellow Oker*, the *English*, the Colour of a
fresh Wheat Straw ; the foreign is somewhat
more deep a Colour : It is much used in com-
mon Painting, being ground very fine.

16. *Yellow Pink* is a greenish Yellow ; it grinds
well, and is good to mix with other Colours, to
make a Green.

Of

Of these Colours, some require washing, as *Red Lead, Blue Bice, Smalt,* and *Verditer;* which is thus performed :

Put the Colour into a glazed Veffel, and put thereto Plenty of clear Water, wash it well, and (after a while) decant the Water. Repeat this Work six or seven Times ; at laft (the Water being but juft troubled) put it into another glazed Veffel, leaving the Dregs at the Bottom ; then put fome more Water into this fecond Vef-fel, and wash it as before, till the Water after fettling be clear, and the Colour remain fine at the Bottom.

Note, Before you take the Colour out of the Veffel, fpread it about the Sides of the Veffel very thin ; and when it is dry, it will Part of it fall down to the Bottom, which keep by it felf ; but that which fticks to the Sides of the Veffel is the beft, and is as fine as any Flower, that ftrike off with a Feather, and keep it for Ufe.

The Colours that require wafhing being thus prepared, (or if they are thofe that do not require wafhing, they are done without) your next Work is to grind them, which is done thus :

Take a Spoonful or two of the Colour you intend to grind, and put to it a little *Linferd-*Oyl, (but be careful you put in too little rather than too much) ; mix them together, and upon your Stone with a Muller, grind them well, ad-ding Oyl by Degrees, as you fee it requires it, to make it like an Oyntment, (always obferving, that it grinds much better when it is thick, than when it is fo thin as to run about the Stone) eve-ry now and then fcrape it up together with a thin Knife, or a Lantern Horn, to keep it at

or

or near the Middle of the Stone, and so continue to work, till you have ground as much as you have Occasion for; which done, clean your Stone, by grinding Sand and Water upon it, and then wash and dry it and the Muller; and when you go to make use of it, mix it with drying Oyl, till it be so thin as to run freely from the Pencil, yet so thick, that the Ground may not appear through it, or to run when it is laid on, and then it will be the more beautiful Colour, and better endure the Weather.

SECT. V.

How to make some Original Colours, &c.

1. To make White-Lead.

TAKE as many Plates of fine Lead as you please, and then put them into an earthen Pot, or *Crucible*, fill the Pot with White-Wine Vinegar, and cover the Top of it close with Clay, bury it in a Cellar, or some moist Place, for seven or eight Weeks, and there will be *White Lead* upon the Plates, which wipe off, and keep for Use.

2. To make Verdigrease.

Hang Plates of Copper over the Fumes of Aqua-fortis, or Spirit of Nitre; or dip the Plates in the same, or in Vinegar, and the Rust or Scurf that is by that Means bred upon the Plates, is *Verdigrease.*

3. To

3. *To make* Ultramarine.

Take *Lapis Lazuli*, the deepeft coloured you can get, having few Veins of Gold in it, cover it clofe up in a *Crucible*, and heat it red hot, and then quench it with Urine, Vinegar, or Water, in an earthen Pot well leaded ; dry it well, then with a Pair of Pincers pull off the hard, white, or grey Parts of it, then grind the reft very fine with honied Water, and dry it, and keep it for Ufe.

Note, The Honied Water is made by boiling a Quart of Water with two Spoonfuls of Honey.

4. *How to make the beft Glue, for glueing the Joints of Boards for Dials, or the like.*

Take Milk that hath ftood fo long, and been fcum'd fo often, that no more *Cream* will arife ; and when fcum'd very clean, boil it a little in a leaden Pot, and if any *Cream* yet arife, be fure to take it clean off ; then put into the Milk a fufficient Quantity of Glue cut in fmall Bits, which will foon melt : Boil it to a good Body, but not too thick nor too thin ; then take it from the Fire, and keep it for Ufe.

Note, You muft take care, that in boyling it you do not burn it to the Sides of the Pot, for that takes away much of the Strength of the Glue ; but if it be made with due care, it binds beyond any other Glue, and is better able to refift the Weather ; and therefore, the fitteft for glueing Boards for Sun-Dials, or the like.

A 2   5. *How*

5. *How to make an exceeding strong Cement or Plai-*
ster, with which to form any Dial-Plain upon the
Side of a House or Wall, and to endure the Wea-
ther, not inferior to Stone.

Take Lime and Sand, and temper it with
Linseed-Oyl to the Consistency of Mortar, or
common Plaister, and spread it upon the Wall
to a competent Thickness, it will become as hard
as Stone, and last many Ages ; and upon this
you may describe a Dial, and put on the Lines,
Figures and Furniture, as before directed.

Note, If you are in the Country, remote from
any Opportunity of getting Linseed-Oyl you may
make it with scum'd Milk, which will be very su-
perior to Plaister made with Lime, Hair, and
Water.

Having proceeded thus far in Colours for
Painting to endure the Weather, it may not be
improper to add something of transparent Co-
lours for the colouring of Maps, or any Draughts
upon Paper or Vellum ; of which, in Order.

First, A Yellow.

The finest that you have Occasion to use, will
be your *French* yellow Berries, which steep'd in
a Gallipot of Water, with a very little Allum,
about 12 Hours, makes a very beautiful Co-
lour.

Secondly, A Red.

Take a Quantity of Brazil, about four Oun-
ces, and boil in a Pint of Grounds of Ale, ad-
ding about a Quarter of a Pint of Vinegar, a
small Quantity of Gum-Arabick, and about an
Ounce

Ounce of Allum ; let them boil very well, and strain the Colour through a fine Linnen Cloth.

Thirdly, *A Sea Green.*

Take a Quantity of Verdigreafe, about four Ounces, boil it in a Pint and a half of Water, firft putting about half an Ounce of Argul to it, let it boil till the Colour ftains pretty deep.

Fourthly, *A Grafs Green.*

Is compounded of the Yellow of yellow Berries, and the Sea-Green mixt according to Difcretion.

The *Fifth*, which is brown, commonly ufed for Roads, Barks of Trees, &c. is burnt Umber, which you muft grind very fine, with fome Gum-water.

Gum-water is only Gum-Arabick fteep'd in Water, till diffolved.

A a 4

A Table of the three Requisites in Dialling, for Latitude 51 deg. 30 min.

Declination	Substile's Distance Meridian		Stile's Height		Inclination of Meridian		Declination	Substile's Distance Meridian		Stile's Height		Inclination of Meridian	
d.	d.	m.	d.	m.	d.	m.	d.	d.	m.	d.	m.	d.	m.
1	00	48	38	29	01	17	22	16	36	35	16	27	18
2	01	36	38	28	02	33	23	17	16	34	57	28	29
3	02	23	38	26	03	49	24	17	56	34	39	29	38
4	03	11	38	23	05	07	25	18	37	34	21	30	47
5	03	58	38	20	06	23	26	19	13	34	01	31	56
6	04	45	38	15	07	39	27	19	50	33	42	33	04
7	05	32	38	10	08	55	28	20	22	33	20	34	12
8	06	19	38	04	10	11	29	21	05	32	59	35	19
9	07	05	37	57	11	27	30	21	40	32	37	36	25
10	07	52	37	49	12	42	31	22	15	32	15	37	31
11	08	38	37	40	13	57	32	22	50	31	52	38	36
12	09	23	37	30	15	10	33	23	25	31	27	39	41
13	10	08	37	21	16	26	34	23	59	31	04	40	46
14	10	54	37	10	17	40	35	24	31	30	40	41	49
15	11	38	36	58	18	54	36	25	04	30	14	42	52
16	12	22	36	43	20	07	37	25	35	29	48	43	55
17	13	05	36	32	21	20	38	26	04	29	22	44	58
18	13	42	36	18	22	33	39	26	35	28	56	45	59
19	14	31	36	03	23	45	40	27	03	28	29	47	00
20	15	13	35	48	24	57	41	27	33	28	01	48	00
21	15	54	35	31	26	08	42	28	01	27	33	49	00

A

A Table of the three Requisites in Dialling, for Latitude 31 deg. 32 min.

Declination.	Substile's Distance Meridian.	Stile's Height.	Inclination of Meridian.	Declination.	Substile's Distance Meridian.	Stile's Height.	Inclination of Meridian.
d.	d. m.	d. m.	d. m.	d.	d. m.	d. m.	d. m.
43	28 29	27 05	50 00	67	36 13	14 05	71 38
44	28 55	26 36	50 59	68	36 25	13 29	72 27
45	29 21	26 07	51 57	69	35 36	12 53	73 16
46	29 46	25 37	52 55	70	36 40	12 11	74 06
47	30 11	25 07	53 53	71	36 55	11 41	74 55
48	30 35	24 38	54 50	72	37 06	11 06	75 44
49	30 58	24 06	55 46	73	37 15	10 29	76 33
50	31 21	23 35	56 42	74	37 24	09 53	77 21
51	31 45	23 04	57 38	75	37 32	09 16	78 09
52	32 05	22 32	58 33	76	37 40	08 40	78 57
53	32 26	22 00	59 28	77	37 47	08 03	79 46
54	32 46	21 28	60 23	78	37 57	07 27	80 33
55	33 06	20 55	61 17	79	37 59	06 49	81 21
56	33 24	20 22	62 10	80	38 04	06 12	82 00
57	33 42	19 49	63 04	81	38 09	05 35	82 36
58	34 00	19 16	63 57	82	38 14	04 58	83 43
59	34 13	18 42	64 49	83	38 17	04 20	84 31
60	34 33	18 06	65 41	84	38 21	03 44	85 18
61	34 47	17 34	66 33	85	38 23	03 06	86 05
62	35 05	17 00	67 24	86	38 26	02 28	86 52
63	35 18	16 25	68 16	87	38 28	01 52	87 39
64	35 34	15 50	69 07	88	38 29	01 15	88 26
65	35 43	15 15	69 57	89	38 29	00 37	89 13
66	36 00	14 40	70 47	90	38 30	00 00	90 00

A Table of Meridional Angles.

Hor. Dial. Lat.	xi. i.		x. ii.		ix. iii.		viii. iv		vii. v.		vi.		South. Dial Lat.
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	
0	0	0	0	0	0	0	0	0	0	0	0	00	90
1	0	16	0	34	1	0	1	44	3	44	90	00	89
2	0	32	1	9	2	0	3	27	7	25	90	00	88
3	0	48	1	44	3	0	5	11	11	3	90	00	87
4	1	5	2	19	4	0	6	54	14	36	90	00	86
5	1	20	2	52	4	58	8	35	18	1	90	00	85
6	1	36	3	27	5	58	10	16	21	19	90	00	84
7	1	52	4	3	6	57	11	55	24	27	90	00	83
8	2	8	4	37	7	55	13	33	27	23	90	00	82
9	2	23	5	9	8	54	15	10	30	17	90	00	81
10	2	40	5	43	9	51	16	44	32	55	90	00	80
11	2	55	6	17	10	48	18	17	35	27	90	00	79
12	3	11	6	51	11	45	19	40	37	49	90	00	78
13	3	27	7	24	12	41	21	17	40	1	90	00	77
14	3	43	7	57	13	36	22	44	42	4	90	00	76
15	3	58	8	30	14	31	24	0	44	0	90	00	75
16	4	13	9	2	15	25	25	31	45	49	90	00	74
17	4	29	9	35	16	26	26	52	47	26	90	00	73
18	4	44	10	8	17	10	28	9	49	4	90	00	72
19	4	59	10	39	18	2	29	25	50	33	90	00	71
20	5	14	11	10	18	53	30	39	51	55	90	00	70
21	5	29	11	41	19	44	31	50	53	9	90	00	69
22	5	44	12	12	20	32	32	58	54	21	90	00	68
23	5	59	12	43	21	20	34	5	55	30	90	00	67
24	6	13	13	13	22	8	35	10	56	37	90	00	66
25	6	28	13	43	22	55	36	12	57	34	90	00	65
26	6	42	14	12	23	40	37	13	58	34	90	00	64

A

A Table of Meridional Angles.

Hor.Dial.Lat.	xi. i.		x. ii.		ix. iii.		viii. iv		vii. v.		vi.		Sout.Dial.Lat.
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	
27	6	56	14	41	24	25	38	11	59	27	90	00	63
28	7	10	15	10	25	9	39	7	60	17	90	00	62
29	7	24	15	40	25	52	40	2	61	4	90	00	61
30	7	38	16	6	26	33	40	54	61	49	90	00	60
31	7	50	16	34	27	15	41	44	62	30	90	00	59
32	8	5	17	1	27	55	42	30	63	11	90	00	58
33	8	19	17	27	28	34	43	20	63	49	90	00	57
34	8	31	17	54	29	13	44	5	64	24	90	00	56
35	8	44	18	20	29	50	44	49	64	58	90	00	55
36	8	57	18	49	30	27	45	31	65	30	90	00	54
37	9	10	19	9	31	2	46	12	66	10	90	00	53
38	9	22	19	34	31	37	46	50	66	29	90	00	52
39	9	34	19	58	32	11	47	28	66	56	90	00	51
40	9	45	20	21	32	44	48	7	67	21	90	00	50
41	9	57	20	44	33	16	48	39	67	47	90	00	49
42	10	10	21	7	33	46	49	12	68	11	90	00	48
43	10	22	21	29	34	18	49	44	68	33	90	00	47
44	10	32	21	51	34	47	50	10	68	54	90	00	46
45	10	44	22	12	35	17	50	46	69	15	90	00	45
46	10	54	22	33	35	44	58	15	69	35	90	00	44
47	11	05	22	53	36	11	51	42	69	53	90	00	43
48	11	17	23	13	36	37	52	9	70	11	90	00	42
49	11	25	23	33	37	3	52	35	70	28	90	00	41
50	11	35	23	52	37	28	53	00	70	43	90	00	40
51	11	45	24	9	37	52	53	24	70	59	90	00	39
52	11	55	24	27	38	15	53	46	71	13	90	00	38
53	12	5	24	43	38	37	54	12	71	28	90	00	37
54	12	13	25	2	38	58	54	29	71	41	90	00	36
55	12	22	25	18	39	19	54	49	71	54	90	00	35
56	12	32	25	34	39	40	55	9	72	5	90	00	34
57	12	40	25	50	39	50	55	28	72	17	90	00	33
58	12	48	26	5	40	81	55	45	72	28	90	00	32

A Table of Meridional Angles.

Hor. Dial. Lat.	xi. i.		x. ii.		ix. iii.		viii. iv		vii. v.		vi.		Sout. Dial. Lat.
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	
59	12	56	26	20	40	36	56	3	72	38	90	00	31
60	13	4	26	34	40	54	56	19	72	48	90	00	30
61	13	11	26	47	41	10	56	34	72	58	90	00	29
62	13	19	27	1	41	21	56	49	73	7	90	00	28
63	13	26	27	13	41	42	57	3	73	15	90	00	27
64	13	32	27	25	41	57	57	17	73	24	90	00	26
65	13	36	27	37	42	15	57	30	73	32	90	00	25
66	13	46	27	49	42	27	57	43	73	39	90	00	24
67	13	51	27	59	42	38	57	54	73	46	90	00	23
68	13	57	28	9	42	50	58	5	73	53	90	00	22
69	14	3	28	19	43	2	58	16	73	59	90	00	21
70	14	8	28	29	43	13	58	26	74	05	90	00	20
71	14	13	28	37	43	18	58	35	74	11	90	00	19
72	14	18	28	46	43	24	58	44	74	16	90	00	18
73	14	22	28	54	43	36	58	52	74	20	90	00	17
74	14	27	29	2	43	52	59	00	74	25	90	00	16
75	14	30	29	7	44	00	59	7	74	30	90	00	15
76	14	33	29	15	44	8	59	15	74	34	90	00	14
77	14	37	29	21	44	14	59	22	74	37	90	00	13
78	14	41	29	27	44	22	59	27	74	44	90	00	12
79	14	44	29	32	44	28	59	32	74	44	90	00	11
80	14	47	29	37	44	34	59	37	74	47	90	00	10
81	14	49	29	41	44	27	59	40	74	49	90	00	9
82	14	51	29	45	44	40	59	44	74	51	90	00	8
83	14	53	29	49	44	44	59	47	73	53	90	00	7
84	14	55	29	42	44	48	59	51	74	55	90	00	6
85	14	56	29	54	44	53	59	54	74	57	90	00	5
86	14	57	29	55	44	55	59	55	74	58	90	00	4
87	14	58	29	56	44	56	59	56	74	58	90	00	3
88	14	59	29	57	44	57	59	58	74	59	90	00	2
89	14	59	29	58	44	58	59	59	74	59	90	00	1
90	15	00	30	00	45	00	60	00	75	00	90	00	

✿✿✿✿✿✿✿✿✿✿✿✿✿✿✿✿✿✿✿✿✿✿✿✿

The USE of the

TABLES.

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THE Design of the first Table, (Entituled
A Table of the Three Requisites in Dialling,
for Latitude 51 Degrees, 30 Minutes,) is to save
the Trouble of Calculation, according to the
Directions given elsewhere in this Book, and
is adjusted to Latitude 51 deg. 30 min. and
to all Declinations in that Latitude. Its Use
is, if it is required to make a Dial for La-
titude 51 deg. 30 min. to decline any Num-
ber of Degrees from the Meridian, seek the
Declination in the first Column, entituled,
(*Declination*) and against it in the second Co-
lumn, you have the Substile's Distance from
the Meridian ; in the third you have the
Height of the Stile, or the Angle that the
Stile makes with the Plain ; and in the fourth
Column, you have the Inclination of Meridi-
ans, or what is by some call'd the Plain's
Difference of Longitude ready calculated.

E X

E X A M P L E.

It is required to make a Dial for Latitude
51 deg. 30 min. to decline from the Meridian
36 deg. (it is no Matter in this Case, whe-
ther the Declination be East or West, the Re-
quisites being the same in Quantity in both,
only upon different Positions,) I look in the
first Column, entituled, (*Declination*) for 36
Degrees the Declination proposed, and I find
against it in the second Column 25 deg. 4
min. for the Substile's Distance from the Me-
ridian, or the Angle, which the Substile makes
with the Meridian, or perpendicular Line of
the Plain. In the third Column I find 30
deg. 14 min. for the Height of the Stile, or
the Angle that the Stile makes with the Plain
of the Dial. In the third, against 36 deg.
you find 42 deg. 52 min. for the Inclination
of Meridians, or the Plain's Difference of Lon-
gitude, which being all found by Inspection in
the Table, you may proceed to make your Dial
as elsewhere directed in this Book, and that
without any more Trouble of Calculation.

And by the same Rule, if you would make a
Dial for the aforesaid Latitude of 51 deg. 30
min. to decline from the Meridian 86 deg. you
find in the Table the Substile's Distance from
the Meridian is 38 deg. 26 m. the Stile's
Height is 2 deg. 28 min. and the Inclina-
tion of Meridians is 86 deg. 52 min. But
in this Case, the Height of the Stile is so
small, that it is best to make the Dial with-
out a Center ; of which before.

<div align="right">The</div>

The second Table, Entituled (*A Table of Meridional Angles*) contains eight Columns, of which the first contains the Latitude propofed for a Horizontal Dial ; and the laft is the Complement thereof, which is alfo the Latitude for direct South Dials ; it is of Ufe in both forts of Dials.

EXAMPLE.

I would make a Horizontal Dial for Latitude 54 Degrees. I look in the firft Column of the Table under (*an Horizontal Dial Latitude*) for 54 Degrees, and againft it in the fecond Column, I find 12 Degrees 13 Minutes, and over the Top of that Column xi. i. which fhews, that the Hour-lines of 11 and 1 make an Angle with the Meridian of 12 Degrees, 13 Minutes. In the third Column, you have 25 Degrees, 2 Minutes, and over that Column is x. ii. *viz.* the Hour-lines of 10 and 2, make an Angle with the Meridian of 25 Degrees, 2 Minutes, and confequently, the Hour-lines of 9 and 3, make Angles with the Meridian of 38 Degrees 58 Minutes. The Hour-lines of 8 and 4 make Angles of 54 29, the Hour-lines of 7 and 5, make Angles of 71 74, the Hour-line of 6 making always right Angles with the Meridian.

EXAMPLE 2.

If you would make a direct South Dial, the Rule is the fame, only you are to find the given Latitude on the right Hand,

or laſt Column of the Table, and pro-
ceed as before ; as ſuppoſe you would make
a South Dial for Latitude 40 deg. you find in
the Table againſt 40, in the laſt Column, that
the Hour-lines of 11 and 1, make Angles
with the Meridian of 11 Degrees 35 Minutes,
the Hour-lines of 10 and 2 make Angles of
23 Degrees 52 Minutes ; and ſo in the reſt, as
in the Table, the Hours on a South Dial being
to be numbred contrary to thoſe of a Hori-
zontal Dial, as hath been ſufficiently taught in
the former Part of this Book.

F I N I S.